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ECONOMIC BOTANY

Devoted to Applied Botany and Plant Utilization

Founded by Edmund H. Fulling

VOL. 15 APRIL-JUNE, 1961 No. 2

Book Reviews

NEWS ITEM

ANNOUNCEMENT

The herbaria of The New York Botanical Garden have been closed since June of 1960 as a result of extensive renovation of the Museum Building housing the herbaria. Although initial schedules pre-supposed the completon of renovation operations within 120 days, it remains unlikely that the Garden's herbarium collections will be accessible to either Garden staff or visitors until July of this year (1961).

During the period of the herbaria closure, more than a hundred requests for loans of herbarium material have been received at the Garden. That the specimens of a considerable number of these requests may no longer be needed is suggested by the cancellation of quite a few earlier made applications for loans.

In view of the probability that the need of many of the still outstanding requests has expired, we request all of our correspondents to submit a renewal of requests for loans, to become effective in July—or as soon thereafter as conditions permit. We hope that our colleagues throughout the world will be understanding of this interruption in the normal course of collaboration.

BASSETT MAGUIRE
Head Curator
The New York Botanical Garden

April 21, 1961.

News of the Society

Second Annual Meeting
of The Society for Economic Botany
Held at Massachusetts Institute of Technology
May 13, 14, 1961

Nearly one hundred members and guests of the Society participated in the Second Annual Meeting at the M.I.T. Faculty Club in Cambridge, Massachusetts. For a society of slightly less than three hundred members, scattered in many countries, this is indeed a good showing!

On Saturday the two sessions of contributed papers (20 in all) reflected the broad interests of the membership. Agriculture, botany, chemistry, ethnology, genetics, and pharmacology were all subjects contributing to a full and well-rounded program. Between these two sessions the luncheon speaker, Professor William H. Weston of Harvard University, gave an entertaining, and scholarly talk entitled "Memo to the S.E.B.—Don't overlook the fungi!" Coffee breaks and a cocktail hour provided opportunity for socializing and for follow up discussion with those who had given papers.

Dr. Ernest Guenther, President, presided at the Annual Business Meeting immediately after dinner and then gave the presidential address. His subject was "Essential oils in South America,"—well illustrated by an excellent colored film. To complete a very full day, attendants adjourned to the Laboratory and Library of Economic Botany, Botanical Museum, Harvard University for an Open House.

The high-light of the meetings was reserved for Sunday morning. A program of invited papers on the theme "Nutrition for an expanding world population," was presented by six outstanding scientists, representing six areas of economic botany. The picture they presented generated both hope and a sense of futility. Man, in the short term view, can probably provide adequate nutrition for the world's population through improvements in the production and use of plant resources but, inexorably, the accelerating rate of population increase will outstrip his best efforts and the eventual solution will have to involve population control. Readers of *Economic Botany* can look forward to the publication of these papers in the near future.

Results of the election of officers were announced at the Annual Business Meeting. Offices to be filled were president and councilmen (2). Elected were:

President: C. O. Erlanson, New Crops Research Branch, USDA, Beltsville, Md.

Councilmen: (3 years)
R. E. Schultes, Botanical Museum, Harvard University, Cambridge, Mass.
I. A. Wolff, Northern Utilization Research and Development Division, USDA, Peoria, Ill.

The Council for the Society elected H. W. Youngken, Jr. to serve as Chairman for another year.

QUENTIN JONES
Secretary

Brief History of Grape Growing in the United States

ARNOLD KROCHMAL[1] and W. GRIERSON[2]

Centuries before the white man set foot on the shores of America, Indians were using wild grapes as a supplement to their diet. In the east the natives used fruit of the fox-grape (*Vitis labrusca*), the riverbank grape (*V. riparia*) and the Scuppernong (*V. rotundifolia*), among others, while in the west *V. arizonica* was made into a crude sort of raisin, particularly by the early Pueblo Indians.

Eastern United States

The earliest settlers on the Atlantic seaboard were deeply impressed by the profusion of wild grapes they saw on every hand. In 1584(5) two of Sir Walter Raleigh's captains, Amadas and Barlowe, described the vines on Roanoke Island as, "in all places . . . both on the sand and on the green soil, on the hills as on the plains, as well as on every little shrub as also climbing towards the top of high cedars that I think in all the world the like abundance is not to be found."

A few years later, in 1606, John Smith (9), impressed by the abundance of wild grapes, noted that they bore crops only in places exposed to the sun, such as along river banks, and near Indian villages, which were usually located in forest clearings. When the Pilgrims had time to explore the Massachusetts shoreline, they too noted the more than ample supply of wild grapes on hand. Governor Thomas Dudley, in a letter to the Countess of Lincoln(3), dated March 12, 1630, sent from "Boston in New-England" wrote, in reference to the settler's explorations, that they "found stores of vines full of grapes dead ripe, we propose . . . to make small quantities of wine. . . ." Two years later, Thomas Morton(4), a native of England who had spent ten years in the Massachusetts Colony, prepared a report of what he called the "New English Canaan." This scholarly and complete work, presented to the king and his Privy Council, has this to say of the native grapes: "Vines . . . there are that bear grapes of three colours, that is to say: white, black, and red. The country is so apt for vines, that . . . the vines would so over spread the land, that one should not be able to pass for them, the fruit is as big of some; as a musket bullet, and is excellent in taste."

And so goes the story—from New York colony, first settled by the Dutch, to the Carolinas and Florida, held by England and Spain, respectively, newcomers from the Old World were amazed and pleased by the bounty of the New World, as exemplified by the grape. Nature seemed, however, to have decided against the *vinifera* grapes in the east, and all attempts to grow them failed. The first such effort is credited to Lord Delaware, who, in 1616 in a letter to the London Company, suggested the grape as a possible source of revenue for the infant colony. Three years later the com-

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pany sent out to Virginia a group of French grape experts and a supply of the most desirable French varieties. The same year the Company enacted a law requiring every householder in the colony to plant and tend ten grape cuttings. The French group failed in its venture largely because of the Indian massacres of 1622 which forced the abandonment of many farms.

For another 150 years, until about the time of the Revolutionary War, Virginia did all in its legislative power to encourage European grape production for wine-making purposes. In 1660 a valuable premium of tobacco was offered for the successful production of wine from home-grown *vinifera* grapes(8). In 1769, the colony undertook the purchase of land, the erection of suitable buildings, and the procurement of equipment for wine production by a Frenchman named Andrew Estevan. The attempt was a failure because of the poor quality of the wine. At about the same time, some of Estevan's countrymen, Huguenot refugees, attempted to grow European vines in the Carolinas and Georgia, but were unsuccessful because of the failure of the berries to ripen. In one state only was there any semblance of success in this pursuit of the goal. In 1662, in Maryland, Lord Baltimore set out 300 acres of European grapes and met with some luck. However, for reasons that are not on record, this project was eventually abandoned.

Even in the rocky, short-seasoned New England area the colonists tried their hand at grape culture. In 1630 Governor Winthrop, an enthusiastic amateur horticulturist, planted a vineyard of *vinifera* grapes on an island in Boston Harbor, with no greater success than his contemporaries.

During these years of almost futile experimentation with European grapes, some of the more imaginative settlers were reaping the bounty of the native varieties. In 1715, in Virginia, Robert Beverly had a vineyard which consisted in part of some of the more desirable wild grapes, from which he produced "good and sound wine."

By 1802 the growing of "wild" grapes had reached a point of sufficient importance for several of the varieties to be named. In that year, from the vineyards of the Kentucky Vineyard Society located at Vevay, Indiana came the Cape grape, supposedly a *vinifera* variety, but actually a native grape. It was widely disseminated as a European grape and paved the way for wide acceptance of the native grapes.

The next impetus to the progress of the young native grape industry was furnished in 1819, when John Adlum obtained cuttings of the still-famed Catawba from a vine in Maryland. From 1825 to 1850 this grape was widely planted in the northeast states and maintained its position of importance until the introduction of the Concord in 1854. As early as 1818 American grapes had become an important part of the agriculture of the Atlantic seaboard states. At York, Pennsylvania, a German farmer named Eichelberger set out four acres of native grapes and gradually increased his vineyard to 20 acres, only one of many similar plantings. In 1825, an early agriculturist estimated the acreage of mature grapevines under cultivation in eastern America as being in the neighborhood of 600 acres. Five years later the estimate rose to 5,000 acres, with most of the grapes being used in wine production.

During this period the muscadine grapes of the south, as exemplified by the justly-famed Scuppernong, were establishing themselves as excellent wine producers.

In 1852 there occurred what is probably the most important event in commercial grape-growing in the eastern part of the United States—the introduction by Ephraim Bull of Massachusetts, of the Concord Grape(2). Almost 100 years later the adaptability and quality of this

grape still keeps it high among the favorites of eastern and Pacific coast grape growers. From 1854 on, it played a major part in the expansion of eastern vineyard acreage.

Another native of Massachusetts is usually credited with being among the first, and certainly one of the most successful, of early grape hybridizers. In 1851 Edward Rogers crossed a red *labrusca* grape, named Carter, with Black Hamburg and White Chasselas(6), two standard European varieties, as the pollen parents. Between 1856 and 1858, 45 selected seedlings of this cross came into bearing and were eventually named after they had been distributed.

In 1852 at the annual meeting of the American Pomological Society held in Philadelphia, Dr. William Valk, of Flushing, New York, exhibited a grape he had named Adam, which was claimed to be a cross between Black Hamburg and Isabella, a *labrusca* grape. For some reason history has turned its back on the good doctor, and his name rarely appears in the annals of grape-breeding. At the same period many others were hard at work in the same field. George Campbell of Ohio crossed varieties of *vinifera, labrusca, aestivalis* and *borquiniana* grapes and eventually produced Campbell's Early.

High in the ranks of the great grape breeders of the last century stands Thomas Munson of Texas, who is said to have introduced more hybrid grape varieties than any other individual or agency. Through Munson's work using *V. linecumii,* the southern states are now able to grow bunch grapes where northern bunch varieties had previously failed.

Pacific Coast and Southwest

The boom in eastern grape production slowed down considerably after the 1880's, when California grapes began to appear on eastern markets. During the period of development of the eastern grape industry, the inhabitants of the southwest and California were busily setting out the grape cuttings brought from Mexico, previously from Spain, by the Franciscan, Capuchin, and Jesuit Fathers. The native grapes, growing wild in the canyons and arroyos, had been used by the Indians, but their small-sized fruit discouraged any attempt by the white man to domesticate them. The padres who established their missions in the west were pleased with the ease with which they were able to propagate their cuttings from Mexico. They established vineyards as part of their program of feeding the Spanish military garrisons and the Indians and of teaching the Indians the arts of civilized agriculture.

About the year 1635 two members of the Capuchin order planted a vineyard of European grapes at the Mission of Our Lady of Socorro, the present location of the city of Socorro, New Mexico, thereby establishing a claim for the title of the first successful vineyard of European grapes in the United States. This planting and the Mission were destroyed in the bloody Indian uprising of 1680. In California the Fathers were equally busy setting out vineyards. The San Diego Mission had one in 1781, and according to old records(7), the missions of San Juan Capistrano, San Luis Rey, San Gabriel, San Buenaventura, and Santa Barbara all raised grapes and pressed wines by 1801. This tradition is carried out to the present day by the Christian Brothers order, which produces wines and brandies.

Now, over 150 years later, the Mission grape still grows in the West, a living monument to the civilizing influences of the good padres who introduced agriculture to that part of the United States. The origin of this variety is shrouded in the fog of history, although it is generally believed to be a seedling of some *vinifera* grape brought from Spain to Mexico, as nothing like it has ever been found growing in Europe.

The grape industry in California did not begin to grow until statehood was achieved in 1850. In that year Jean Louis Vignes blazed the trail for the great industry-to-be, by establishing a vineyard of 40,000 vines in Los Angeles, propagated from selected cuttings brought from his native France. The "father" of the grape industry of California was Colonel Agoston Haraszthy, who in 1858 set out a vineyard of 80,000 plants near Sonoma. In 1861 the Colonel went to Europe, at the request of the Governor of California, and returned with about 100,000 vines, representing over 1,400 varieties. Mainly through his efforts were vines brought to California from Persia, Asia Minor, and Egypt.

With the introduction of desirable varieties production shot up rapidly. In 1855(7) the state had approximately 1,000,000 vines. In 1870(7) the figure was up to 28,000,000 vines. Although the early Spanish and the nineteenth-century Americans did most to develop the California grape industry, the Russians in the settlements north of San Francisco at Bodega and Fort Ross are credited with the introduction of the Madeira grape.

The industry developed at a rapid pace. The demand for wines and brandies was heavy, and since both these products were non-perishable, it was possible to send them by ship to the eastern markets. The ease with which grapes could be propagated, the relatively short number of years that elapsed before a full harvest, and their remarkable adaptation to California growing conditions all were prime factors in the grape industry.

In 1887 California grapes reached Philadelphia, thus opening up almost unlimited markets to the western producer. In the late 1880's, the advent of the refrigerated car spurred the expansion of vineyard plantings. Gradually the improved shipping facilities exerted their influence on the varieties planted. Old standards, such as Black Hamburg and Chasselas D'or which did not ship well, were replaced with Tokay, Emperor, Thompson Seedless and others, all good shippers with high keeping quality.

Although California almost monopolizes the table grape, raisin grape, and wine grape industries, the eastern states, notably New York and Ohio, have managed to maintain a grape juice industry by virtue of their adaptability to Concord grape production. California, however, has not been idle, and research workers are hard at work trying to breed a vinifera grape which can be grown in California as a substitute for the Concord. The new variety Scarlet shows real promise of meeting this need. New York's champagne industry in the Finger Lakes is the source of a top quality beverage.

The grape industry is constantly moving forward. State and federal workers are threshing out the problems that harass the grape grower and are constantly trying to help in the production of higher quality fruit. New varieties are being bred, others are being imported from abroad. Rootstocks are being tried out, and insect and disease problems worked on.

The hardiness of the grape, its unmatched ability to set a crop under poor growing conditions, its use for valuable products such as juice, wine, and brandy, and its wide adaptability seem to assure it a prominent place in American agriculture for a long time to come.

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Knowledge of Poisonous Plants in the United States—Brief History and Conclusions[1]

JOHN M. KINGSBURY[2]

Domestic experimental or case evidence stands behind only about half the names in current U. S. compilations of poisonous plants. A significant number of the remainder rest upon 19th century experience, mainly European sources. Several useful conclusions may be derived from an historical survey of the development of this body of knowledge.

Introduction

Information found in current compilations dealing with poisonous plants of the United States represents an accumulation of specific items of knowledge, a few of which reach back to the time before written records were used. A continuum may be traced in this accumulation along the familiar lines of development of Western civilization in which scientific experimental approach is a relatively recent innovation. In many cases, repeated citation from ever newer sources clothes an item of information with unjustified authority. It is often difficult to determine what is soundly founded and what is less so. For example, experiment station bulletins on poisonous plants rarely represent the product of original research, yet sources of information are usually not cited. As one attempts to trace an item of information into older literature he is faced with additional problems. Difficulties of availability are compounded by obscure references to ancient literature that require professional bibliographic knowledge to identify.

I believe that compilers dealing with poisonous plants have often felt an obligation to carry a plant into newer literature even though uncertain of the original authority. This carry-over serves the useful function of drawing attention to the plant, but may perpetuate error, and may appear to validate what was established on tenuous evidence. This review sets forth the general nature of sources available to persons who first gathered information on poisonous plants of the United States, and upon whose original compilations the more recent are based.

Foundations in Western Tradition

The observation that knowledge of poisonous principles preceded agrarian civilization is curious yet logical. Hunters used poisons on their weapons to bring down game in the time before crops came under cultivation. Accurate observations of plants which might be employed in this manner, and in the healing art, had great value and were accumulated over the centuries. In the Western tradition, Dioscorides' manuscript "of medicinal matters" (30) represents the preeminent compilation of supposed active properties of plants to the first century A.D. Even Dioscorides had trouble with his sources. Speaking of the asclepiads, he states, "But they have transmitted the powers of medicines and their examination cursorily, not estimating their efficacy by experience, but by vain prating about the cause, having lifted up each medicine to a heap of controversy: and besides this they have recorded one thing by mistake for another . . .", and of one particular asclepiad, "And in the face of plain evidence he sets down many such falsehoods, which are tokens that he acquired his information not by his own observation,

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but had it only from the false relation of hearsay."

Many centuries elapsed before a work dealing specifically with poisonous plants appeared. The herbals—both the manuscripts of the Greek and Roman eras and the printed volumes of the period of the reawakening—served as the repository of comments on the poisonous nature of plants. Little is gained by close examination of the period between Dioscorides and the birth of the the scientific method other than to establish that, during this time when much other knowledge fell into disuse, poisoning became truly an art. Practitioners developed, jealously guarded, and carefully transmitted secrets of poisonous compounds. Extraneous ingredients or procedures were introduced into recipes further to obscure the identity of the toxic principle, but were thus to some extent introduced also into contemporary literature. The flavor of the times has been captured by reviewers such as Blyth (6), Kobert (37), and Lewin (39).

The printed herbal appeared around 1470 and its era lasted for about two centuries (2). Dioscorides was translated from Latin into English in 1652-5 by John Goodyer (30). Many herbals were based upon or made frequent reference to this work. In the process of the occasional attempt to equate plants of Northern Europe with those of Dioscorides, additional confusion occurred. Only gradually did erroneous information and superstition give way to contemporary observation. The herbals were succeeded in one direction by works dealing with medicinal and useful plants and in another by floras. In both, the poisonous nature of particular plants was frequently mentioned. Such references, for example are not infrequent in the voluminous writings of Linneaeus. Compilations limited to poisonous plants, animals, and minerals made their appearance at about the beginning of the 18th century. These are divisible into two categories—those concerned with the results, causes, and treatment of poisoning (toxicologies) and those presenting an enumeration and description of poisonous plants and other poisonous substances.

European Publications Dealing With Poisonous Plants—The 18th Century

The subject-index cards of the library of the United States Department of Agriculture (62), relatively comprehensive for the period and subject in question, list more than a score of works in Latin, French, English, and German published during the 17th and 18th centuries which dealt exclusively with poisonous plants or other poisonous substances. Several were learned papers on relatively narrow subjects, for example, the classic work of J. J. Wepfer, 1679, *Cicvtae Aqvatica, Historia et Noxae,*[3] but more often they were compendia.

The following 18th century works deserve brief note. In 1701 Melchoir Friccius, a physician of Ulm published a *Tractus de virtute venenorum medica* (24), and in 1710, *Paradoxa de venenis* (25). Richard Mead in 1702 published *A Mechanical Account of Poisons in Several Essays* (43) which set forth an ingenious explanation of the mechanisms of poisoning. In 1765 appeared Lieutaud's *Synopsis Univ. Praxeos Medicae* (41) in two volues. This in the original and in translation became a standard reference for physicians, the second volume being a text on the materia medica.

Johann Frederick Gmelin's *Abhandlung von den giftigen Gewächsen* (26) published in 1775 and in a second, expanded edition, in 1805; *Allgemeine Geschichte der Pflanzengifte* (27) in 1777, second edition in 1803; and *Allgemeine Geschichte der Gifte* in 1776 and

[3]This work is cited by several of the early authors on poisonous plants. A translation of part of it may be found in a paper by Jacobson (36).

1777 (28, 29) were particularly influential. The first gives insight into knowledge of the times. In its preface the author states that he has been encouraged to publish in his native tongue the lectures which he had prepared in Latin for the Roman Imperial Academy of Natural Sciences (probably similar to or the same as those published as *Diss. de materia toxicorum hominis vegetabilium simplicium in medicamentum convertenda*, Tübingen, 1765). His information was drawn largely from earlier literature. Cases of poisoning in human beings are cited with particular attention to poisonings resulting from injudicious use of plant-derived medicines. Attention is given also to the effects of poisonous plants on animals. The book follows an organization that is still commonly used. A brief treatment of general aspects of poisoning is followed by individual discussions of 56 species in 30 genera:

(*Aconitum lycoctonum, A. napellus, Actaea spicata, Aethusa cynapium, Agaricus muscarius Anemone nemorosa, A. pulsatilla, A. ranunculoides, Arum maculatum, Asarum europaeum, Atropa belladonna, Bryonia alba, Caltha palustris, Chaerophyllum bulbosum, C. sylvestre, C. temulum, Chenopodium hybridum, Cicuta virosa, Clematis flammula, C. vitalba, Colchicum autumnale, Conium maculatum, Daphne mezereum, Datura stramonium, D. tatula, Digitalis purpurea, Euphorbia amygdaloides, E. chamaesyce, E. cyparissias, E. esula, E. exigua acuta, E. helioscopia, E. paralias, E. peplus, E. platyphyllos, E. sylvatica, E. verrucosa, Helleborus foetidus, Hyoscyamus niger, Lolium temulentum, Mercurialis perennis, Pedicularis palustris, Polygonum hydropiper, Ranunculus acris, R. aquatilis, R. arvensis, R. bulbosus, R. ficaria, R. flammula, R. lingua, R. platanifolius, R. sceleratus, Sium latifolium, Solanum dulcamara, S. nigrum vulgare, Veratrum album.* All species named by Linnaeus).

Several of these plants would not be included in such a work today. In Gmelin's later works the number of species considered was greatly augmented.

Nine years later, Pierre Bulliard published a slightly more extensive treatise, *Histoire des plants vénéneuses et suspectes de la France*. In the second edition (1798) (10), eighty-six species of poisonous plants, in 54 genera:

Aconitum, Actaea, Aethusa, Anemone, Aristolochia, Arum, Asarum, Asclepias, Atropa, Betonica, Bryonia, Chelidonium, Cicuta, Clematis, Colchicum, Conium, Cyclamen, Daphne, Datura, Digitalis, Euphorbia, Evonymus, Genista, Gladiolus, Gratiola, Hedera, Helleborus, Hyoscyamus, Iris, Juniperus, Lobelia, Lolium, Menyanthes, Momordica, Nigella, Oenanthe, Ononis, Paeonia, Papaver, Paris, Pedicularis, Phellandrium, Polygonum, Prunus, Ranunculus, Rhinanthus, Rhus, Ruta, Secale, Sedum, Solanum, Taxus, Veratrum, Agaricus.

are listed and discussed. Compared with Gmelin, more extensive treatment is given to symptoms, effects, and antidotes. two additional publications of that century, Plenck's *Toxicologia, seu doctrina de venenis et antidotis* (51), 1785, and Woodville's *Medical Botany* (69), three volumes and supplement, 1790 to 1794, were much consulted. A passage from the latter provides insight into the condition of literature of that time. "It is a lamentable truth, that our experimental knowledge of many of the herbacious simples is extremely defective; for as writers on the Materia Medica have usually done little more than copy the accounts given by their predecessors, the virtues now ascribed to several plants are wholly referable to the authority of Dioscorides."

The preceding were learned works intended for use by physicians and educated laity. It was important, too, that the public be informed about dangerous plants. In the common schools, two works of J. C. A. Mayer (55), appearing between 1798 and 1800, were employed. They serve as an index to the plants then considered most dangerous in Germany, namely, *Cicuta virosa, Datura stramonium, Conium maculatum, Hyoscyamus niger, Atropa belladonna, Aethusa cynapium, Ranunculus sceleratus, Solanum nigrum, Daphne mezereum,* and *Lolium temulentum.* Mayer's death prevented publication of another volume to

have included *Sium latifolium, Anemone pratensis, Digitalis purpurea, Colchicum autumnale, Oenanthe fistulosa,* and *Oenanthe napellus.*

European Publications Dealing With Poisonous Plants—The 19th Century

European literature on medicinal or useful plants in general, and on poisonous plants in particular, increased geometrically during the 19th century. It is possible to mention only a few of the most outstanding works that discussed poisonous plants.

M. J. B. Orfila, who has been called (6) the "Father of Toxicology," was widely known in his time as a chemist and as the author of several texts. He investigated the chemistry of toxic substances, including those found in plants, performing hundreds of experiments. His *Traité des Poisons tirés des Règnes minéral, végétale et animal,* published in two volumes in 1814 and 1815 (47), presented results of his experiments and observations in cases of poisoning in human beings. The dog served as his chief experimental animal. To obtain experimental results it was often necessary to prevent vomition by ligating the esophagus. This rather drastic procedure undoubtedly was responsible for symptoms which in some cases he ascribed to the toxicity of the plant in question. He attempted to trace the route and site of accumulation of the poisonous substance and to recover it from the tissues, an approach not previously used. His works are organized on the basis of the characteristics of the poisonous substances. Waller's translation (49) treats poisonous plants under the categories of acrid poisons, of narcotic poisons, and of narcotic-acrid poisons. Orfila reported experiments demonstrating the toxicity of some 45 species of plants. About as many again are included on the basis of references from other literature. An American edition of the English translation was published in 1817 (48). The following quotation is from the translator's preface "Every physiological and chemical question, however futile, or practically useless, has engaged the attention, nay become the mania of European physiologists, the English and the French, as well as the Italians and the Germans; but until lately none had devoted himself to the numerous affectations produced by poisons. . . . For the practitioners in the United States, to throw into one register the fatal cases by poison for one year, what an awful reproach would it cast upon deficiency of practice in this particular! . . . The work of Dr. Orfila is considered to be of more importance to the physicians of the United States than it can be to those of any other country, because we are less capable of producing such a work than almost any other nation, older than ourselves."

I have an anonymous booklet dated Dresden 1815 and entitled *Giftbüchlein oder Abbildung und Beschreibung der in Deutschland wachsenden Giftpflanzen* (1). It was obviously intended to familiarize the lay public with the most dangerous poisonous plants. Although almost contemporary, it is more extensive than Mayer's *Einheimische Giftgewächse* and includes all the plants which Mayer published except *Lolium temulentum.* In addition are listed *Physalis alkekengi, Euphorbia esula, Solanum dulcamara, Colchicum autumnale,* five species of *Ranunculus, Anemone pratensis, Anemone nemorosa, Cynoglossum officinale, Paris quadrifolia, Aconitum napellus,* and *Digitalis purpurea.* The 24 colored illustrations are botanically faithful and better than some in current publications of similar purpose.

Brandt, Phoebus, and Ratzeburg's *Abbildung und Beschreibung der in Deutschland wild wachsenden und in Gärten im Freien ausdauernden Giftgewächse* (7) appeared in 1838. This served as a primary reference for at least two of the more influential authors later to appear

on the American scene. It is given prominent mention by Pammel in his *Manual of Poisonous Plants* (50) of 1911. A charge card in the copy of the *Abbildung* possessed by the Library of the United States Department of Agriculture indicates that the book was in the hands of V. K. Chesnut (see later) during the years he was concerned with poisonous plants. The first volume of the *Abbildung*, the work of Brandt and Ratzeburg, is a revised, expanded edition of a work by the same authors that appeared in 1834. It deals with phanerogamous plants. The second volume, by Phoebus, deals with cryptogamous plants and was not preceded by a earlier edition. The section concerning phanerogamous plants discusses only 56 species:

(*Aconitum, Aethusa, Anemone, Arum, Atropa, Caltha, Cicuta, Colchicum, Conium, Coronilla, Cyclamen, Cynanchum, Daphne, Datura, Digitalis, Euphorbia, Fritillaria, Gratiola, Helleborus, Hyoscyamus, Juniperus, Lactuca, Ledum, Lolium, Mandragora, Narcissus, Nerium, Oenanthe, Papaver, Paris, Pulsatilla, Ranunculus, Rhus, Scopolina, Sium, Solanum, Taxus, Veratrum.*)

but treats them rather fully. Many species found in Gmelin and/or Bulliard are omitted although these sources are frequently cited for the plants listed. Orfila is, perhaps, most frequently used. A strong botanical emphasis is reflected in extensive botanical characterization of families, genera, and species, and in listing of synonymy. A discussion of poisonous principle accompanies each plant and includes reference to articles in journals of the time dealing with chemistry and physics. Usually the space devoted to discussion of toxicity of the plant is much less than that devoted to botanical matters.

Berge and Riecke's *Giftpflanzen-Buch* (4), published in 1845, also served as an important source for later investigators. It provides an excellent vantage point for consideration of the literature of poisonous plants at mid-19th century and is particularly useful because it contains well-identified references for each plant discussed and is more extensive than the work by Brandt and Ratzeburg. Organized as a catalog, it uses sub-divisions commonly employed in current works on poisonous plants: synonyms, common names, distribution and habitat, time and duration of flowering, properties of the active principle, optionally a brief treatment of the use in medicine, and a list of literature citations. Literature on the materia medica has always been greater than that restricted to plants from the point of view of their toxic capacities alone. Medical accidents contributed much to the knowledge of poisonous principles in plants. Berge and Riecke placed considerable reliance on works on the materia medica for their toxicological information. Discussion of 178 non-cryptogamous species in this work represents a great increase over earlier authors. This increase is due in large part to the inclusion of species from areas such as the East Indies, the West Indies, South America, and Africa, where active exploration was taking place.

The work of the 19th century most frequently cited in later publications is the book of Charles Cornevin, *Des Plantes Vénéneuses et des Empoisonnements qu'elles déterminent* (20), published in 1887. Cornevin, professor at L'École National Vétérinaire, presents in this volume, a small amount of experimental work as well as material meticulously collated from many sources. He treats 338 species of non-cryptogamous plants. Some of the large increase represented in this figure is attributable to additional plants described as toxic from other parts of the world but much appears to be through the citation of additional species, often without clear substantiation, in genera previously known as toxic. One gains the impression that he added many species to his lists on the basis of relationship rather than evidence. He visu-

alized plants as containing many interacting active principles which might modify the characteristic physiology of the individual principle as extracted. He was concerned with the distribution of the toxic principle or principles in the plant; lability in cooking, drying, and similar influences; chemistry of the toxic principle; factors affecting the development and strength of the toxic principle in various plants; and the like. This publication was the first to emphasize the veterinary point of view regarding toxicity of plants to animals.

European Knowledge of Poisonous Plants—Summary

Knowledge of poisonous plants in Europe is seen to have developed directly from recorded observations by Greek and Roman writers, recollected and amplified during the period of the printed herbal. The herbals reflected interest in the distribution, relationships and usefulness of plants. Floras, works on the materia medica, and pharmacopoeias developed from herbals. Lastly, works devoted solely to poisonous plants appeared. The 18th century saw an attempt to place information on poisonous plants in the public domain by bringing it from Latin into languages of common use. The information itself stemmed from a great variety of observations, but chiefly from observations of accidental cases of poisoning and from the results of overuse of plants as medicinal "simples." The 18th century, with pioneers such as Priestley, Lavoissier, Berthollet and Scheele, was the period when chemistry as a science was born, and chance observation began to give way to experimental investigation. In the study of poisonous plants this development was reflected first in Orfila's experimental approach. For a complete picture of information concerning particular poisonous plants in the 18th and 19th century it would be necessary to refer to floras, toxicologies, works on poisonous plants, works on the materia medica, and learned papers in journals. Of these, the most reflective of the state of knowledge are those devoted solely to poisonous plants. In comparing the major works cited above (Gmelin, 1775; Bulliard, 1798; Berge and Riecke, 1845; and Cornevin, 1887) two conclusions stand out. First, the number of species considered poisonous increased many fold during this period. Secondly, each author dropped from consideration a significant number of species treated by those before him.

Such, in brief, was the information available by 1900 to persons interested in poisonous plants in the United States.

Development of Experimental Agriculture and Veterinary Medicine in the United States

The inception of chemistry as a science in the United States may be traced to Priestley's arrival here in 1794. At about the same time, courses in chemistry, botany, and geology were introduced by the leading colleges. Jefferson's administration, which began in 1801, did much to promote the cause of science in the still young country and opened the door to an experimental approach in agriculture. But the experimental approach was not forthcoming for several decades for reasons associated with the exigencies of pioneering, clearing of the land, the westward movement, wars and unsettled political conditions, and most important because the landowners were not convinced of the value of such an effort. The Department of Agriculture was founded in 1862. In the same year federal aid (Morrill Land Grant Act) was made available to the states to further agricultural education, which was practically non-existent at that time. The necessity for experimentation was felt almost immediately wherever a program for agricultural education was developed. Federal agricultural experimentation

commenced in 1855 (in the Patent Office) but was greatly expanded after the organization of the Department of Agriculture. The early appointees were trained for, and worked in entomology, chemistry, and botany. The first state college appointees were similarly educated (35, 60).

In the United States investigations of poisonous plants have been concerned primarily with their effects on animals. These studies required the application of veterinary skills. The 1850's saw attempts at the establishment of veterinary colleges, associations, and journals. The first veterinary college successful in graduating students was the New York College of Veterinary Surgeons (private) which enrolled its initial class in 1864-5. Veterinary instruction commenced in the land grant agricultural colleges of New York (Cornell), Illinois, and Massachusetts in 1868. The early students in these institutions served as a major source for veterinary personnel in the wide variety of programs subsequently established under federal and state auspices (40, 68).

Early Literature

Early reports of poisonings caused by plants in this country are heterogeneous. For example, in 1842, H. S. Randall, described (54) a gangrenous disease of cattle in the area around Cortland, New York, and astutely observed that it might be caused by ergot because of its similarity to ergot-caused gangrene of human beings in Europe. It is interesting to note that he published in an English veterinary journal because none was then available in the United States. The disease in man known as milk-sickness, more recently shown to be caused by consumption of milk from cattle poisoned by ingestion of *Eupatorium*, may be traced back in the United States to the early 1820's (46). However, it cannot really be considered a part of the literature of poisonous plants at that time because its etiology remained unknown for many years and was still in dispute as late as 1900. In 1854, F. P. Porcher published a paper in which he discussed poisonous and useful cryptogamous plants of the United States (52). His information on toxic qualities of the plants discussed was drawn almost entirely from European sources. This paper was expanded into a book in 1857.

A short paper by W. W. Bailey (3) appeared in 1873 in which were discussed fifteen genera of plants poisonous by ingestion and a few others producing dermatitis. Unfortunately he cited no references. It is impossible to tell how much of his information came from domestic sources, personal observation, or elsewhere. Other cases reported in early years included poisoning of livestock by *Euphorbia*, by molds on grain, and by algae. Both loco poisoning and selenium poisoning were recognized in the West but were the subject of considerable confusion until later.

Questions concerning poisonous plants came with increasing frequency to veterinary departments at state colleges and to the United States Department of Agriculture. Investigations resulting from requests of the United States Department of Agriculture for aid in problems concerning poisonous plants are recorded in early Department Reports. The department botanist made several determinations of suspected plants, and the chemist analyzed many for toxic compounds (19, 63-65).

Ergotism in Kansas, 1884

In 1884 a crisis of considerable dimension drew public attention to poisonous plants and initiated a formal program of investigations by the Department of Agriculture. A cattle disease, characterized by sloughing of the hoofs and other symptoms, was reported from Kansas in that year. A local veterinarian diagnosed it as the highly contagious foot and mouth disease. Substance was given his

diagnosis by the fact that foot and mouth disease was then extant in the Northeast, having been brought in with the importation of diseased cattle from Europe. The imminence in Kansas, of a quarantine on cattle, at that time the primary resource of the state, caused great public excitement (21, 22). Several eminent veterinarians were detailed by the Army Veterinary Service, by various state governments, and by the Canadian government to investigate the situation, and conflicting reports soon appeared (23, 33, 34, 38). The Bureau of Animal Industry had just been organized in the Department of Agriculture. From it, M. R. Trumblower was sent to make an investigation (61). As a result of increasing public concern, D. E. Salmon, just-named chief of the Bureau, also investigated (57, 58). The correct diagnosis of non-infectious ergotism made by Salmon and several others eventually prevailed but the incident served dramatically to emphasize problems for which poisonous plants could be responsible.

Investigations on Poisonous Plants, 1884-1900

Various other problems concerning poisonous plants came almost immediately under investigation, and the literature increased tremendously between 1884 and 1900. Part of the increase may be traced to the influence of the Hatch Act (1887) under which federal funds were made available to the states in support of agricultural experimentation. The problems investigated included ergotism and several other diseases of suspected fungal etiology (reflecting the contemporary interest in microorganisms); higher fungi; loco poisoning (certain species of *Astragalus* and *Oxytropis*); crotalism or "bottom disease" (*Crotalaria* spp.); larkspur (*Delphinium* spp.); water hemlock (*Cicuta* spp.); the toxicity of sorghums (*Sorghum vulgare* Pers.); lupines (*Lupinus* spp.); death camas (*Zygadenus* spp.); castor bean (*Ricinus communis* L.); bitterweed (*Helenium autumnale* L.); sleepy grass (*Stipa robusta* Scribn.); and mechanical injury of stock caused by various plants, especially squirrel-tail grass (*Hordeum jubatum* L). All of these problems occurred in, or were investigated by, states west of the Mississippi River between 1884 and 1900. Of the 21 states in that area, 16 had published on problems involving poisonous plants before 1900 and all but three by 1903. In sharp contrast were the states east of the Mississippi. Here, experiment station investigations of particular problems appear to be limited to the single investigation of toxicity of wild cherry (*Prunus* spp.) by the New Hampshire station (45). Only a few additional plants received investigation under other auspices in the East.

Several review papers appeared in the period 1884 to 1900. Those appearing in states west of the Mississippi (5, 66, 67) were concerned largely with problems of western poisonous plants, and with the dissemination of information obtained in this country. On the other hand, review papers appearing in the East (31, 32, 56), while derived partially from local case histories, also drew heavily on European sources. Millspaugh's *American Medicinal Plants*, published in 1887 (44), is well documented with references and may be used as an index to the medical literature of the time. It derived much information from European and American compendia preceding it, and from case histories reported from various countries. Two later review papers dealing with poisonous plants in the United States were compiled in large part from this work (9, 59).

Federal Investigations on Poisonous Plants

It is not possible to trace the lines of investigation that have been pursued un-

der various auspices in the United States since 1900 and that have resulted in the publication of several thousand articles. Instead, a brief survey of the investigations carried on by the United States Department of Agriculture may serve as an example of activity during this period. In 1894 V. K. Chesnut, a chemist, was hired as assistant botanist in the Division of Botany (which became in 1901 the Bureau of Plant Industry) to work exclusively on problems involving poisonous plants. This event marks the inception of organized federal concern with poisonous plants which has continued to the present. Botanists, chemists, and veterinarians have been cooperatively associated in the work from the beginning although the program has been reorganized with various changes in administration of the Department of Agriculture. Chesnut's reports (11-18), widely distributed, contain a synthesis of information from the literature with an on-the-spot survey of the problems of poisonous plants in the West (chiefly in Montana at the request and with the cooperation of the Montana Experiment Station) and a small amount of experimental work. His retiring presidential address to the Chemical Society of Washington (17) discusses the state of knowledge of the chemistry of poisonous principles in plants at that time. He continued with the Department until 1904, doing some work in Washington similar to that done in Montana. In 1905 the Division of Drug and Poisonous Plant Investigations was created in the Bureau of Plant Industry. Despite this relationship, many of the early reports are to be found in the Reports of the Bureau of Animal Industry. A field station was established in 1905 at Hugo, Colorado, in cooperation with the Colorado Agricultural Experiment Station. Work, primarily with loco, was carried on here for four years. A second station was established during the same period at Imperial, Nebraska, with the cooperation of the Nebraska Experiment Station. From 1909 to 1911 a station was maintained at Gunnison National Forest (Colorado), cooperatively with the Forest Service, for the investigation of larkspur. Work was done also on lupine and water hemlock. The station was moved to Greycliff, Montana, for investigations of lupine and death camas from 1912 to 1914. In 1915, investigations on poisonous plants were transferred to the Pathology Division of the Bureau of Animal Industry. A permanent and more convenient station was established that year, under the new administration, in the Fishlake National Forest near Salina, Utah. Many problems, but particularly oak, loco, and milkweed, were attacked there. Prominent names in federal investigations of poisonous plants at these stations include C. D. Marsh, A. C. Crawford, A. B. Clawson, W. W. Eggleston, Hadleigh Marsh, J. F. Couch, and W. T. Huffman. In 1955 the Salina station was closed and the experimental work moved to Logan, Utah, under the direction of Dr. Wayne Binns.

Conclusions

This review leads to some interesting conclusions. From experimental investigations more is known about poisonous plants of the West than the East in the United States. Of the three major reasons for this, the most important, in my opinion, is that the West was settled concurrently with the development of facilities for and interest in agricultural experimentation in the United States. Farmers of the settled East, on the other hand had developed, by experience, empirical husbandry practices which on the whole prevented mass loss of stock to unknown poisonous plants, such as occurred in the West. Secondly, the similarity of the flora of the East to that of Europe made it possible for easterners to use information from European works on poisonous plants. The flora of the West includes many plants not found in such

works. Finally, the problem of poisonous plants is greater in the West than in the East, both in number of poisonous species and in severity of poisoning.

These generalizations require modification for the southeastern states in which investigational activity has greatly increased in the last decade or two, largely in response to increased interest in cattle, poultry, and potentially useful agricultural by-products such as citrus seed meal.

An analysis of sources of information from which plants have been designated as poisonous in the United States shows that only about a third are so designated from experimental investigations performed in this country. The proportion rises to nearer two-thirds if to the former are added those considered poisonous from reports of cases in the United States. The rest are listed on the basis of information not obtained in this country, and of these a significant proportion must be traced into the literature of the 19th century for substantiation.

This has both advantages and disadvantages. On the one hand, European findings do not always apply here. For example, in the case of lupine which has caused serious loss in the western United States, recent domestic publications of reputation carry the observation that icterus is a characteristic symptom or the most prominent in lupine poisoning. This statement originally derived from European literature of the late 1800's, was valid in Europe but is not valid in the United States. Supposedly a fungus which occurs on European lupine, but not here, accounts for the difference. On the other hand, there is much to be said for maintaining a name on the roles of poisonous plants, even though the original source of information is old and not domestic. The following case, from the author's experience, is an example. In Ithaca, N. Y., a serious case of poisoning in a child was traced to ingestion of several berries from *Daphne mezerum*. Although relatively common, this plant does not appear to have been reported toxic on experimental evidence or clear case history anywhere within the United States. In fact some of the currently cited figures for its toxicity may be traced to Orfila (1814). The plant itself is mentioned by Dioscorides. In this instance, because *Daphne mezereum* was listed in the current work available to the physician involved, the drastic treatment for plant poisoning was undertaken and the child made a satisfactory recovery.

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Steroidal Sapogenins. LXI. Steroidal Sapogenin Content of Seeds

A number of **Yucca, Agave** *and* **Nolina** *seeds have been analyzed for steroidal sapogenins. The content of sapogenins in the seeds of several* **Yucca** *species is particularly high.*

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The results of a detailed study (7) of the steroidal sapogenins of the Joshua tree (*Yucca brevifolia*) indicated that the seeds of this species contained an unusually large quantity of saponin (analyzed as sapogenin). Because of the industrial possibilities of any seed crop, we wanted to ascertain whether other related species and genera also contained high sapogenin content in their seeds. A number of botanists, particularly H. S. Gentry, L. N. Gooding, B. H. Warnock, A. M. Woodbury and Miss Bess Peacock, collected seeds of several species of *Yucca*, two *Agave*, and one *Nolina* for analysis. The results are shown in Table I.

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Sapogenins occur in plants only in the form of glycosides called steroidal saponins. The analytical procedure involves an acidic hydrolysis of the saponins to yield the steroidal sapogenins that can then be weighed and identified (1). The actual saponin content of seeds is, therefore larger, often twice that of the values shown in Table I. Since sapogenin is the useful form, the values given may be used in any assessment of the economic value of the seeds.

In general, the results for the various *Yucca* species justify the conclusion that saponins are concentrated in the seeds of the genus. Previously the leaf had been

TABLE I
STEROIDAL SAPOGENIN CONTENT OF SEEDS

Species	Location	Sapogenin % MFB		Sapogenins found in the leaf
Agave lecheguilla	Big Bend, Texas	hecogenin + manogenin	1.5	Smilagenin
Agave schottii	Southern Arizona	hecogenin	1.7	smilagenin gitogenin
Nolina texana	Southern Arizona	unidentified	1.8	none
Yucca arizonica	Southern Arizona	sarsasapogenin	12.0	sarsasapogenin
Yucca baccata	Superior, Arizona	sarsasapogenin	6.8	sarsasapogenin
Yucca brevifolia	St. George, Utah	tigogenin	8.0	hecogenin, tigogenin
Yucca elata	Oracle, Arizona	Sarsasapogenin	0.9	sarsasapogenin
Yucca intermedia	Las Cruces, N. Mex.		0.0	none
Yucca mohavensis	San Diego, Calif.	sarsasapogenin	6.6	*
Yucca peninsularis	Baja, Calif.	tigogenin	1.7	tigogenin
Yucca schottii	Fort Huachuca, Ariz.	sarsasapogenin	4.9	sarsasapogenin
Yucca whipplei	Murrieta, Calif.	tigogenin	1.9	tigogenin
Yucca sp.	Southern Arizona	sarsasapogenin	4.5	sarsasapogenin
Yucca sp.	Sonora, Mex.	sarsasapogenin	6.2	sarsasapogenin
Yucca sp.	Chihuahua, Mex.	sarsasapogenin	7.9	*

*Not determined.

considered to contain the highest amount of sapogenin, at least in *Yucca* and *Agave* species. Studies of the sapogenin content of the leaves of many *Yucca* and *Agave* indicate that 1 to 2% sapogenin on a dry basis was the maximal quantity obtainable (3, 4, 5). Of the 12 samples of *Yucca* seed tested, eight contained at least 4.5% sapogenin; of these, five ranged from 6.6-12.0%. The predominant sapogenin found was sarsasapogenin. Occasionally, tigogenin was present. In almost all cases the same sapogenins were found in the seeds and leaves.

Too few examples of *Agave* and *Nolina* seed were obtained to permit generalizations. The concentration of the sapogenin in the seed was not unusually high for the seeds we tested. Moreover, the sapogenins in the seed and corresponding leaf were different.

Previously, we have shown that sarsasapogenin could be converted to cortisone (2). The large amount of sarsasapogenin in the seeds and the absence of interfering substances make the extraction and isolation of this sapogenin a simple process similar to that described for tigogenin from Joshua tree seeds (7). *Yucca* species are hardy and will grow in almost any location in the United States (6), but much agronomic and genetic research will be required before *Yucca* can be recommended as a cultivated crop. Since seeds are often high in protein and/or oil, *Yucca* seed should be investigated for these possibilities.

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Effect of Gibberellin on the Fibers of Hemp

The effect of gibberellin on the hemp plant is described. Gibberellin-treated plants show greater number of fibers as compared to controls. The individual fibers are larger in diameter, more lignified and up to ten times as long as the fibers from the untreated plants. Economic potential of application of gibberellin to hemp and possibly other fiber-yielding crops is suggested.

C. K. ATAL[1]

During the past thirty years botanists have been working on growth substances produced by a rice disease fungus, *Gibberella fujikuroi* (7). Yabuta and Sumiki (16) isolated and characterized these substances and named them gibberelin. Four gibberellins (12), A_1, A_2, A_3 (gibberellic acid) and A_4, were isolated from the filtrates of *Gibberella fujikuroi.* Increase in height is the most outstanding effect of gibberellins on plants. Stowe and Yamaki (11) reviewed the effect of gibberellins on plants and concluded that "cell elongation in most cases seemed to predominate as a result of gibberellin applications." Greulach and Haesloop (2) found no increase in the size of cells when length of internodes of *Phaseolus vulgaris* increased 2.28 fold. They concluded that cell division was promoted. Sachs and Lang (9) showed that application of gibberellin increased cell multiplication in the subapical region of rosettes of *Hyoscyamus niger.* Guttridge and Thompson (3) showed that increase in length of strawberry petioles, brought about by application of gibberellic acid, was accompanied by increase both in number and length of epidermal cells. Feucht and Watson (1) showed that number and length of internode cells are increased in the gibberellin-treated seedlings of *Phaseolus vulgaris.*

The work on the effect of gibberellins on cell number and cell length has primarily been concerned with the study of thin walled parenchyma of epidermis, cortex and pith. No attention has been paid to the effect of gibberellins on the number, length, and thickness of stem fibers. Any effect on the number, length or lignification of fibers, as a result of gibberellin treatment, could be of possible commercial value. Although literature describing the effect of gibberellins on plants is voluminous, literature describing the effect of gibberellin on economic crops is limited (8, 11, 13, 14, 15). The present study deals with the effect of gibberellin on the internal and external morphology of *Cannabis sativa* L. with special reference to the effect on pericyclic fibers.

Material and Methods

Cannabis sativa seedlings of uniform height and vigor were selected at a stage when they had developed three internodes and four to six leaves. Twenty of the selected seedlings were transplanted to eight-inch clay pots and shaded for one week to allow them to recover. Ten plants were used as controls and ten were treated with gibberellin. They were then removed to partial shade. On February 23, 24, and 25 three successive applications of 100 ppm gibberellin (Pfizer) in distilled water were sprayed on the leaves. Afterward, the plants were sprayed with the same solution once every week for a period of ten weeks. The stem height (to the shoot apex) of all the plants was recorded at the time of first application and subsequently at weekly intervals (Figs. 1, 2, 3). Other characters such as the number, length and diameter of the internodes, the number of leaves on the

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Fig. 1. (Left) Treated and control plants of Cannabis sativa, *one week after the first application of gibberellin.*

Fig. 2. (Right) Treated and control plants of Cannabis sativa *four weeks after the first application of gibberellin.*

main stem, presence or absence of lateral branches, fresh and dry weight of the stem, time of flowering and effect on root system, were recorded four weeks after the first application.

Six weeks after the first application of gibberellin a quantitative evaluation of the bast fibers was made. Thin transverse sections from the midpoint of the stem were treated with phloro-glucinol-hydrochloric acid reagent, which stained the lignified pericyclic fibers and facilitated measurements. The bast from the middle of the longest internode of each stem was macerated in a solution of equal volumes of 10% chromic acid and 10% nitric acid. Macerations were also made from plants that had attained their maximum height under natural conditions. Measurements were made of the lengths of individual fibers isolated from the macerates. Fibers from plants harvested ten weeks after the first application were also studied.

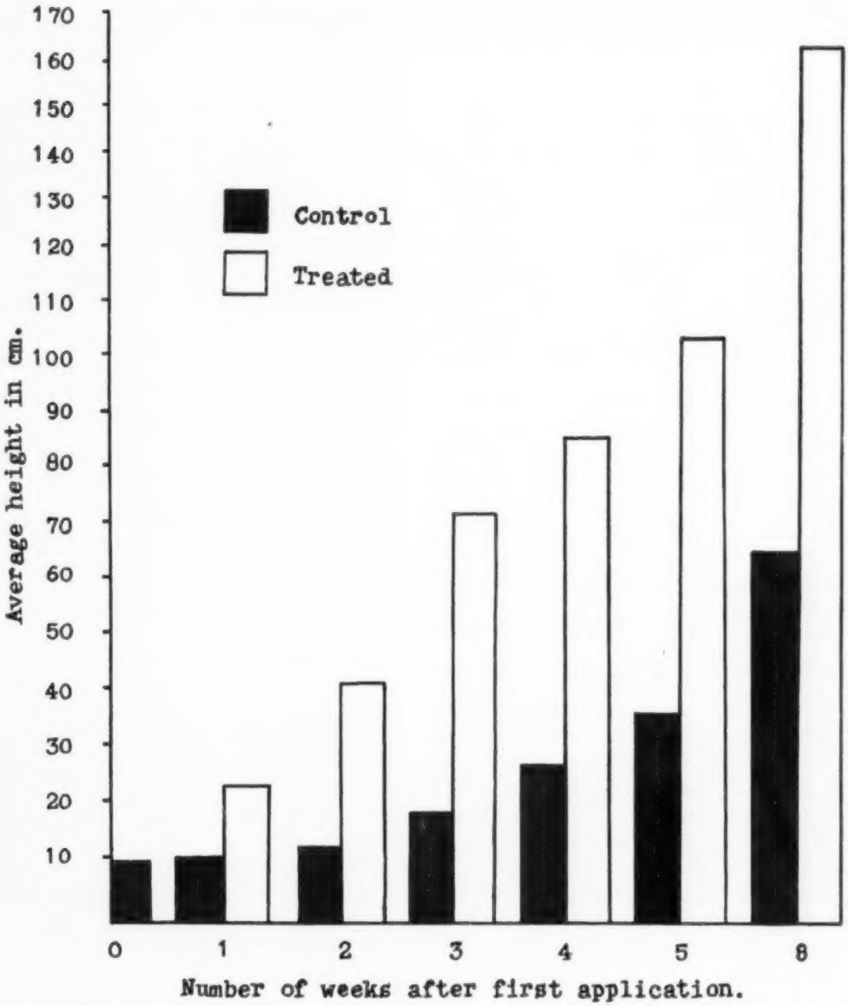

Fig. 3. The stem elongation of Cannabis sativa *in response to gibberellin application at different time intervals.*

Observations

Data regarding the growth characteristics of treated and control plants are recorded in Table I. Bark/wood ratio and average fiber dimensions are presented in Table II. The plants responded to gibberellin rapidly and a visible difference in the height of treated and untreated plants was discernible within 24 hours after the first application. General effects of gibberellin application are described below:

Stem: The most outstanding effect was stem elongation due largely to increase

TABLE I
QUANTITATIVE COMPARISON OF GIBBERELLIN—TREATED AND UNTREATED PLANTS OF *Cannabis sativa* FOUR WEEKS AFTER THE FIRST APPLICATION.

Character	Treated	Controls	Percent Increase
Number of nodes	8	7	14.3%
Number of leaves on the main stem	16	14	7.15%
Total leaf area	variable	variable	——
Height of plant	80 cm.	23 cm.	247.0%
Lateral branches	none	8	——
Midstem diameter	0.45 cm.	0.25 cm.	80.0%
Maximum internode length	20 cm.	2.5 cm.	700.0%
Fresh weight of stem	4.7 g*	1.2 g*	290.0%
Root system	poorly developed	developed normally	——
Flowering onset	same time	same time	——

*These figures are averages of three plants; all other figures are averages of ten plants.

in internode length. As will be clear from Table I, average maximum internode length was eight times as great as that of the controls. The stems of the treated plants were more robust, thicker in diameter and were not ribbed like the untreated plants. The terminal two or three internodes of the treated plants were weak and required support six weeks after the first gibberellin treatment. The lateral shoots of treated plants were completely suppressed whereas shoots arose in the axil of each leaf of control plants. If the growing point of treated plants was severed, lateral shoots developed in the axils of leaves. If the first application of gibberellin was applied to plants on which lateral shoots had already developed, the lateral shoots elongated.

Leaves: Four weeks after the first application of gibberellin the number of leaves on treated plants was not significantly greater than the number of leaves on the controls. The total leaf area varied so much from plant to plant on both treated plants and controls that no significance could be attached to this factor.

Root system: In general the root systems of gibberellin-treated plants were poorly developed in comparison with the root systems of untreated plants. Such inhibition of root system by gibberellin has been recorded for other plants (10). However, in one of the treated plants the root system was better developed than the control plants (Fig. 4).

Flowering: The number of flowers of both male and female plants was markedly increased. The size of axillary racemes (♂ flowers) as well as axillary spikes (♀ flowers) was greatly increased. The genetically female plants showed sex reversal in the early stage of flowering. Sex expression of genetically male plants was not effected.

Discussion

Fiber of hemp, like that of flax and jute, is produced in the bast tissue. The economic value of such a plant is based on the amount of fiber produced. Therefore, increased height of the plant and increased stem diameter are desirable. Gibberellin treatment causes an average increase of about 250% in diameter of the stem (Table I). Treated plants also show an average increase of 290% in the fresh weight of the stem. That this increase is not due to greater deposition of wood is shown by the higher bark/wood ratio of treated plants. A higher bark/wood ratio indicates a high proportion of bark in the stem and is a desirable feature (5) in case of plants which contain bast fibers. Lateral branches of hemp are completely suppressed by gibberellin treatment. According to Kar (4), restricted branching is of value to a fiber crop where fiber is

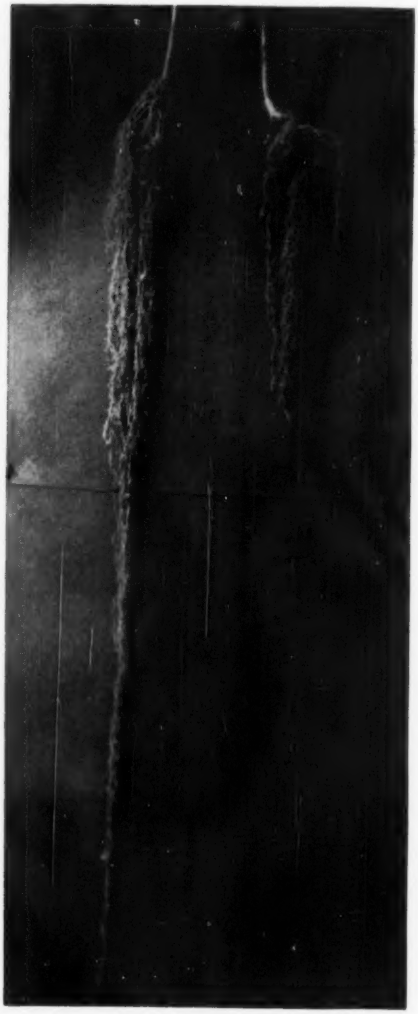

Fig. 4. The root system of treated (left) and untreated (right) Cannabis sativa *plants.*

in the stem. In the treated plants there is up to 100% increase in the number of fibers as seen in the transverse section (Figs. 5, 6). Also, the component fibers are larger in diameter, more lignified and about 10 times as long as those of controls (Table II). The increase in the length of individual fibers is more or less proportional to the increase in the internode length. Increased length of the fibers is to be expected due to increase of internodal length. Kundu (6) showed that the longest fibers of jute are located in the longest internodes.:

It appears that gibberelin may prove to be of economic importance when applied to economic fiber crops like hemp. There is need for further work on this problem. Work is also being conducted on *Crotalaria* and *Corchorus* species.

Conclusions

Gibberellin in the form of a 100 ppm aqueous spray when applied at weekly intervals to young hemp plants caused characteristic morphological responses including marked stem elongation, increased internodal length, suppression of lateral branches and poor development of root system. Gibberellin increased the fresh and dry weight of stem, bark/wood ratio and number of fibers. The individual fibers of treated plants are larger in diameter, more lignified, and up to ten times as long as the bers of untreated plants. Commercial value of the application of gibberellin to hemp is suggested.

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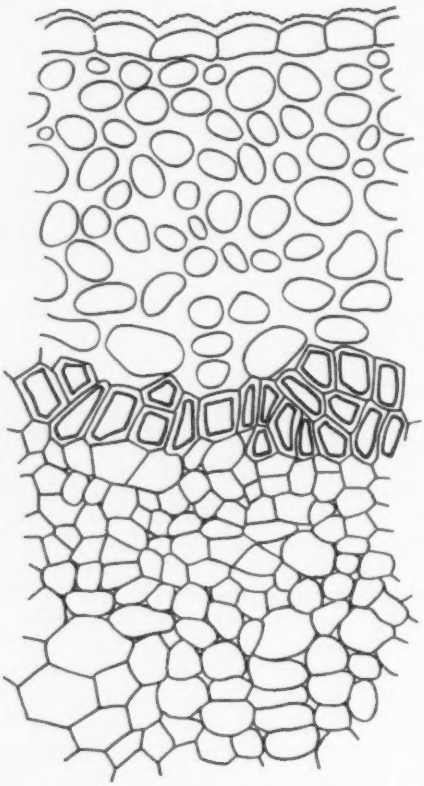

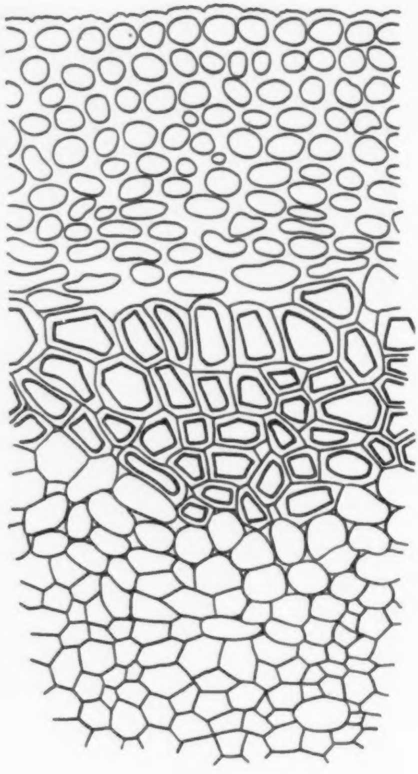

Fig. 5. (Left) Transverse section of the bark of untreated Cannabis sativa *showing the pericyclic fibers.*
Fig. 6. (Right) Transverse section of the bark of a gibberellin-treated plant showing abundant development of fiber.

TABLE II
Comparison of Fiber Characteristics of Six-week-old Treated, Controls and Mature Hemp Plants.

Character	Treated	Control	Mature Plants*
Bark/wood ratio, fresh	.369	.324	———
Bark/wood ratio, dry	.53	.51	———
Average fiber length	3.0-4.5 cm	0.3-0.5 cm	0.8-1.2 cm
Average fiber diameter	19.2-28.8 μ	12.0-21.0 μ	———
Average fiber wall thickness	6.0-9.0 μ	3.0-6.0 μ	———

*These were mature plants which had obtained their optimum height under natural conditions.

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Relationship Between Physical Characteristics and Milling Score of Kernels of Soft Wheat Varieties[1]

RICHARD A. POPHAM, RICHARD H. EYDE,[2] RICHARD J. NASKALI,[3] and PIEN-CHIEN HUANG[3]

I. Thickness of Endosperm Cell Walls

Wheat varieties differ in the ease with which the kernels can be converted to flour. This fact is of considerable commercial and technological importance. Not only does the miller desire a high total flour yield, but also a good yield of patent flour and a low ash content in his product.

A method of evaluating milling quality of Pacific Northwest wheat varieties by means of an experimental milling has been developed by E. F. Seeborg (10). Each variety is given a milling score derived from the following formula:

> milling score = 100—[(80-per cent flour yielded in milling) + 50 (per cent ash in flour—.30) + .4 (feed time in min.—15) + .2 (65-per cent patent flour yielded) + .5 (16-per cent moisture content)].

The fact that a sizeable portion of grain is needed for an experimental milling is a problem to the plant breeder. When he develops a new wheat variety by crossing a few plants each of two previously known varieties, he must, in subsequent crop years, increase the first few grams of grain obtained from that cross until more than 500 g. has been accumulated. If a method were available by which the milling characteristics of a new variety could be estimated from a few kernels, the breeding program could be shortened by three to five years. This investigation was undertaken with the hope of developing such a method for the evaluation of soft wheat for the use both of the breeder and of the miller.

It should be emphasized that the Seeborg milling score was devised for use in evaluating Pacific Northwest wheat varieties. Although it is being used to some extent for the evaluation of eastern soft wheats, it has not been shown to be a reliable means of ascertaining varietal milling quality of these wheats. It is therefore hoped that sufficient information will eventually be forthcoming to allow an appraisal of the Seeborg milling score with respect to its validity as a measure of their milling quality.

Much attention has already been given to the problem of milling quality in Pacific Northwest wheat varieties. Larkin *et al.* (6) studied varietal differences in the thickness of grain coats of these wheats. Statistical analysis of their data revealed no relationship between the thickness of any or all of the grain coats and Seeborg milling scores. Mecham *et al.* (8) failed to find any relationship between crude fat content and milling characteristics of Pacific Northwest wheat varieties. The percentage of pentosans extracted from kernels of Pacific North-

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[1]Papers from the Department of Botany and Plant Pathology, The Ohio State University, Columbus 10, Ohio, Nos. 645, 646, 647. A report of work done under contract with the U. S. Department of Agriculture and authorized by the Research and Marketing Act. The contract was supervised by the Northern Utilization Research and Development Division of the Agricultural Research Service.

[2]Coauthor of parts I and II only.

[3]Coauthors of part III only.

west wheat varieties is inversely correlated with Seeborg milling scores, according to Elder *et al.* (2). These workers found no correlation between milling scores and test-weight, crude fiber content, or nitrogen content. Wolf *et al.* (12) could not relate the composition of water insoluble hemicelluloses of endosperm cell walls to milling properties. In the same paper, however, the authors stated that treatment of transections with acid or alkali degraded cell walls over a greater area in varieties of good milling than in varieties of poor milling quality. Larkin *et al.* (5) reported an inverse correlation between Seeborg milling scores and the thickness of endosperm cell walls measured 20-200 μ from the aleurone layer. However, varietal differences in thickness of the aleurone cell walls were not related to milling differences.

One of the objectives of the present study was to ascertain whether the thickness of starchy endosperm cell walls might be related to milling quality in eastern soft wheats as in Pacific Northwest wheat varieties.

Selection of Samples

All wheats used grew in experimental plots at the Ohio Agricultural Experiment Station, Wooster, Ohio during 1955 and 1956. Wheat from the 1955 crop consisted of eight varieties: Blackhawk, Wabash, American Banner, Thorne, Trumbull, Clarkan, Fairfield, and Kawvale. The first seven are soft wheats. Kawvale has been classified as a hard wheat (1), but it was included with the realization that it might yield anomalous data. Wheat from the 1956 crop consisted of the same eight varieties plus Lucas and Butler, which are soft wheats.

Wheat samples as well as milling scores were provided by the U.S.D.A. Soft Wheat Quality Laboratory located at the Ohio Agricultural Experiment Station, Wooster, Ohio. In both 1955 and 1956, harvested grain of each variety was milled in a Buhler mill to obtain the necessary data. Seeborg milling scores obtained from wheats of the 1955 crop will be referred to as "1955 milling scores," and those from the 1956 crop as "1956 milling scores."

An unmilled portion of wheat of each variety was reserved each season. Kernels in each portion were inspected at the Soft Wheat Quality Laboratory, and half of the kernels, including immature, damaged, diseased, and smaller kernels, were discarded. The remaining kernels of each varietal portion were used for experimentation. Samples of the eight wheat varieties from the 1955 growing season and the 10 varieties from the 1956 growing season will be referred to as "1955 samples" and "1956 samples" respectively.

Methods

Kernels from 1955 samples were softened by soaking in distilled water at 4°C. for three days, then sectioned on the freezing microtome. Sections 30 μ thick were cut from the middle third of each kernel, stained with Bismarck brown for about one minute, and thoroughly rinsed with distilled water. The Bismarck brown stain was prepared by mixing 1 g. Bismarck brown Y with 100 ml. distilled water and 5 g. phenol crystals.

In order that walls could be seen clearly enough for measuring, the sections were agitated in a flask of water until cells in the region near the aleurone layer were mostly free of cytoplasm and starch. The best sections were then mounted in distilled water (Fig. 1). Measurements were made only on those cell walls which were normal to the surface of the slide. A vernier ocular micrometer was mounted on the tube of a microscope fitted with a 10x ocular and a 90x objective (oil immersion) and was checked by measurement of a standard scale on a stage micrometer. To determine the accuracy of the measuring technique, the same cell wall was measured repeatedly, the cell

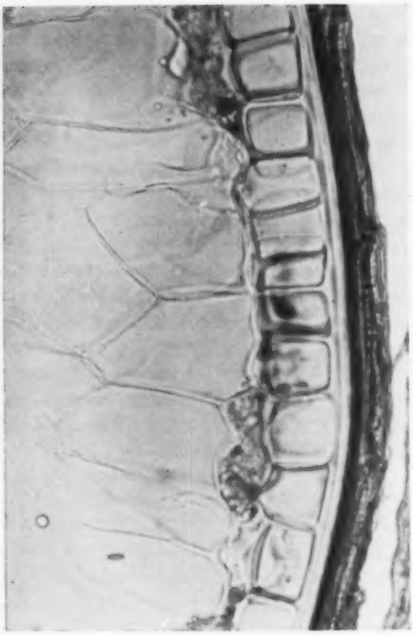

Fig. 1. Photograph of a cross section of the back portion of a kernel of Fairfield wheat. Cells have been freed of starch and cytoplasm and are ready for measurement. Aleurone cells are 40-50μ long measured normal to the grain coats.

wall image being brought in and out of focus each time. Twenty values obtained in this way had a range of 0.2 μ. All cell wall measurements were taken from the inner edge of one cell wall to the inner edge of the adjacent cell wall; therefore the "cell wall thickness" actually means the total thickness of two cell walls and a middle lamella. Five kernels of each variety were taken at random from 1955 samples, and 25 different walls were measured in each kernel, making a total of 125 measurements per variety. Thirteen of the cell walls measured in each kernel were located in the cheeks, and 12 were located in the back No walls located in the crease region were measured, for walls there are curved and irregular in thickness. All measurements were taken on radial walls of the starchy endosperm cells at a distance of 20 μ from the inner edge of the aleurone. The 20 μ distance from the aleurone layer was used because Larkin *et al.* (5) found that differences in cell wall thickness are most easily detected in that region.

The measurement of endosperm cell walls is a difficult and time-consuming task. Moreover, measurements made by different workers may differ relatively greatly. During our investigation, some endosperm cell walls of three Pacific Northwest wheat varieties were measured for comparison with values reported by Larkin *et al.* (5). Our measurements fell into the same varietal order as those of Larkin, but Larkin's measurements were at least 0.5 μ higher for each variety.

Results and Discussion

The mean thickness of the endosperm cell walls and the milling score for each variety represented by 1955 samples are given in Table I. Inspection of the data reveals that thicker walls are associated with lower milling scores and thinner walls with higher milling scores. The absolute value of the correlation coefficient obtained by analyzing these data exceeds the corresponding 5% value found in a table of correlation coefficients (9); hence it can be inferred with greater than 95% confidence that a negative correlation exists between the milling scores and wall thicknesses. If data for Clarkan and Kawvale, two varieties which are known to have some hard wheat characteristics, are not included in the calculations, the inference can be made with greater than 99% confidence.

A scatter diagram, based on the values in Table I, was prepared (Fig. 2). The line drawn through the scattered points is the regression line for these values. The slope of the regression line represents the average decrease in milling score for each

TABLE I

MEAN ENDOSPERM CELL WALL THICKNESSES (BASED ON 125 MEASUREMENTS TAKEN 20 μ FROM THE ALEURONE LAYER) AND MILLING SCORES. BOTH SETS OF DATA WERE OBTAINED FROM 1955 SAMPLES.

Variety	Mean endosperm cell wall thickness in microns	1955 milling score
Blackhawk	2.07	89.5
Wabash	2.19	87.5
Thorne	2.23	84.2
Clarkan	2.23	84.0
Am. Banner	2.26	86.2
Kawvale	2.28	87.4
Trumbull	2.30	85.7
Fairfield	2.45	81.2

unit increase in endosperm cell wall thickness.

Endosperm cell wall thicknesses of three varieties from the 1956 crop, Butler, Lucas, and Thorne, were measured for comparison with 1955 measurements. Mean measurements and corresponding milling scores are given in Table II.

Mean endosperm wall measurements obtained from 1956 samples of Butler, Lucas, and Thorne are very much alike. If wall thicknesses are correlated with milling scores, one would expect the 1956 milling scores of these three varieties to be very much alike. However, they differ considerably. Moreover, walls of 1956 kernels were much thinner than those of 1955 kernels with comparable milling scores. The 1956 milling score of Thorne, for instance, was about the same as the

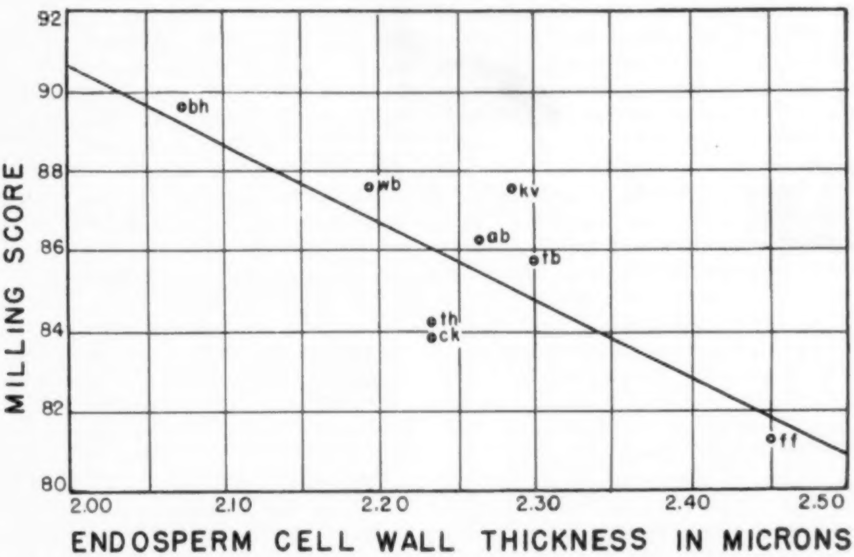

Fig. 2. Graph illustrating the relationship between endosperm cell wall thickness, measured 20 μ from the aleurone layer, of 1955 samples and 1955 milling scores. Varieties represented are: Blackhawk (bh), Wabash (wb), Thorne (th), Clarkan (ck), American Banner (ab), Kawvale (kv), Trumbull (tb), and Fairfield (ff).

TABLE II

MEAN ENDOSPERM CELL WALL THICKNESSES (BASED ON 125 MEASUREMENTS TAKEN 20 μ FROM THE ALEURONE LAYER) OF THREE VARIETIES FROM 1956 SAMPLES AND THEIR 1956 MILLING SCORES.

Variety	Mean endosperm cell wall thickness in microns	1956 milling score
Butler	2.13	86.9
Lucas	2.13	84.3
Thorne	2.09	81.2

1955 milling score for Fairfield, but the wall thicknesses were 2.09 μ and 2.45 μ respectively.

It is understandable that thin-walled varieties from the 1955 season have higher milling scores than thick-walled varieties, because thin walls are more easily torn during the milling process, thus making the conversion of starchy endosperm cells to flour swifter and more complete. Thin walls close to the aleurone layer, where the measurements were taken, are especially conducive to high flour yields, since the separation of starchy endosperm from the bran occurs in this region. Furthermore, varieties which have thinner walls near the aleurone layer probably have thinner walls throughout the starchy endosperm. This inference is supported by the work done on Pacific Northwest wheats by Larkin *et al.* (5), who found that milling scores are inversely correlated with endosperm wall thicknesses in the region from 20 to 200 μ from the aleurone layer.

Endosperm cell walls of 1956 kernels of Butler, Lucas, and Thorne were thinner than endosperm cell walls of kernels of most varieties in the 1955 samples. Also the average endosperm cell wall thicknesses of Butler, Lucas, and Thorne were very similar, even though the three varieties had milling scores which were different from each other (Table II). Any or all of the following may account for these discrepancies:

(1) Perhaps it is only between varieties with extremely high and extremely low milling scores that differences in endosperm cell wall thickness can be detected. This explanation is supported by the scatter diagram in Fig. 2. If it had not been for the relatively large difference in cell wall thickness between Blackhawk and Fairfield varieties, there would have been no evidence for a relationship between cell wall thicknesses and milling scores.

(2) The investigator making the wall measurements may have an increasing tendency to choose thin walls. Since it is necessary to select for measurement straight walls which are normal to the surface of the microscope slide, it is possible that thinner walls are chosen with greater frequency as the task becomes more routine and tedious. This source of error could perhaps be reduced if measurements are made by more than one investigator.

(3) Seasonal fluctuations in wall thickness may sometimes be of sufficient magnitude to obscure varietal differences. This possibility is not considered likely for two reasons. An investigation of four Pacific Northwest wheat varieties (7) resulted in the inference that "station and year of growth of the sample do not significantly affect the cell wall thickness." Furthermore, evidence presented in Part II leads us to believe that varietal differences in the amount of water imbibed by kernels during a 24-hour period are due to varietal differences in wall thickness. If this inference is true, thickness of endosperm cell walls of 1956 kernels should be similar to those of 1955 kernels, because imbibition data are similar to 1955 imbibition data.

The length of time required to make a suitable number of measurements, possible difficulties related to human visual differences, and seasonal disparity of data all militate against the predicting of milling scores by this method. The experiment is of value, however, for the 1955 results are further evidence that thickness of

endosperm cell walls is related to milling quality. Development of a more reliable method for detecting very small differences in thickness of these walls might provide a means of accurately predicting milling quality.

Summary

Kernels of nine soft wheat varieties and one hard wheat variety were studied in an attempt to find varietal differences which are related to differences in milling quality as expressed by Seeborg milling scores.

Thickness of radial walls of starchy endosperm cells was measured 20 μ from the aleurone layer. A correlation was found between measurements obtained from 1955 kernels of eight varieties and their milling scores. Good milling quality is related to thinner walls, poor milling quality to thicker walls. No appreciable varietal differences were found, however, when endosperm cells walls of 1956 kernels of three varieties were measured. This is interpreted to mean that the human eye and the microscope are not always adequate for detection of slight differences in wall thickness that influence milling quality.

II. Imbibition of Water

This investigation was initiated in an effort to discover whether Seeborg milling scores (10) vary in proportion to the amount of water imbibed by kernels of some soft wheat varieties. Such a hypothesis was suggested by the observation that milling moisture is included as one of the five factors in the Seeborg milling score formula. It was suspected that an inverse relationship exists because if tempering time is not carefully regulated, poor milling quality wheats rather quickly imbibe so much water than the endosperm becomes tough and will flake rather than pulverize between the rollers, resulting in low flour yields.

Materials & Methods

After ascertaining that weighed samples of several wheat varieties do imbibe different amounts of water during the same soaking time, a method was developed for determining the amount of water which the kernels of a given variety can imbibe.

The test samples of wheats used were of the same varieties and origin, and were prepared in the same manner as described for samples used in a previous experiment (Part I). Wheat samples as well as milling scores were provided by the U.S.D.A. Soft Wheat Quality Laboratory located at the Ohio Agricultural Experiment Station, Wooster, Ohio.

Ten kernels of each variety from the 1955 samples were weighed to the nearest mg. and then were immersed in distilled water. After 24 hrs. each set of 10 kernels was dipped 10 times in 100 per cent ethanol to remove surface water, dried for exactly three min., and weighed again. Weight increase resulting from imbibition was divided by inital weght to compute the percentage weight increase for each variety. Soaking periods of longer and shorter duration were tried, but 24 hrs. soaking yielded data which most nearly corresponded to 1955 milling scores.

The procedure was repeated using 10 sets of 10 kernels each from each variety. Average values obtained were analyzed statistically to ascertain whether a correlation exists between these data and 1955 milling scores.

In order to ascertain whether initial moisture content of kernels influenced results of the experiment just described, imbibition tests were performed on 1956 samples. Some kernels of each variety were dried in an oven for nine days at 55°C. and were stored in a desiccator until they were immersed. Others were not

subjected to any special treatment before soaking. In each case the test was performed 10 times for each variety, using different kernels for each replication.

Results

Average values for 10 imbibition tests performed on 1955 samples, 1955 milling scores, and milling score ranks are given in Table III.

The anomalous position of Kawvale in the imbibition table is not surprising, since that variety has been classified as a hard wheat (1). Inquiry into the nature of Clarkan variety revealed that it, too, has some hard wheat characteristics, probably due to hard wheat ancestry (1, 4). Imbibition data from these two varieties were therefore excluded when conclusions were drawn regarding the relationship between imbibition properties and milling scores of soft wheats.

The relationship between imbibition data and milling scores of 1955 samples of the six soft wheat varieties (Table III) is shown in Fig. 3. A regression line has been drawn through the scatter diagram. This graph could be used by a plant breeder to predict the milling score of a new variety of soft wheat, if the new variety had been grown under the same experimental conditions as the other six varieties. After calculating the average percent weight increase due to soaking for 24 hrs., the value could be used as an abscissa. The corresponding ordinate intersecting the abscissa at the regression line would have a value corresponding to that of the predicted 1955 milling score. For instance, the predicted milling score of a variety which had imbibed 60% of its own weight would approximate 85.6. The curved lines in Fig. 3 are 95% confidence limits. If a breeder were to predict a 1955 milling score of 85.6 for the new variety, he could be 95% confident that the actual milling score would lie between 84.2 and 86.9.

The imbibition data obtained from 1956 samples (Table IV) are similar to those obtained from 1955 samples. Moreover, drying the kernels in an oven did not appreciably change the varietal order of the average imbibition values. The 10 individual test values from which each average value was calculated were, however, more variable for oven-dried kernels than for untreated kernels.

Imbibition values were, on the average, 12.3% higher for oven-dried kernels than for untreated kernels. In the fifth column in Table IV, imbibition values obtained from oven-dried kernels are presented with 12.3% subtracted from each value to better show the similarities among the three sets of imbibition data.

Since imbibition data obtained from 1955 samples are so similar to data from 1956 samples, it is startling to find that milling scores for the two seasons differ greatly. Most scores derived from 1956 samples are considerably lower than those obtained by milling samples of 1955 wheat (Table V). It is not surprising,

TABLE III

COMPARISON OF IMBIBITION DATA FROM 1955 SAMPLES AND 1955 MILLING SCORES.

Variety	Per cent increase in weight due to imbibition of water	1955 Milling score	Milling score rank
Blackhawk	54.7	89.5	1
Wabash	55.1	87.5	2
Clarkan	57.5	84.0	7
Am. Banner	59.6	86.2	4
Thorne	61.4	84.2	6
Trumbull	62.6	85.7	5
Kawvale	62.8	87.4	3
Fairfield	66.0	81.2	8

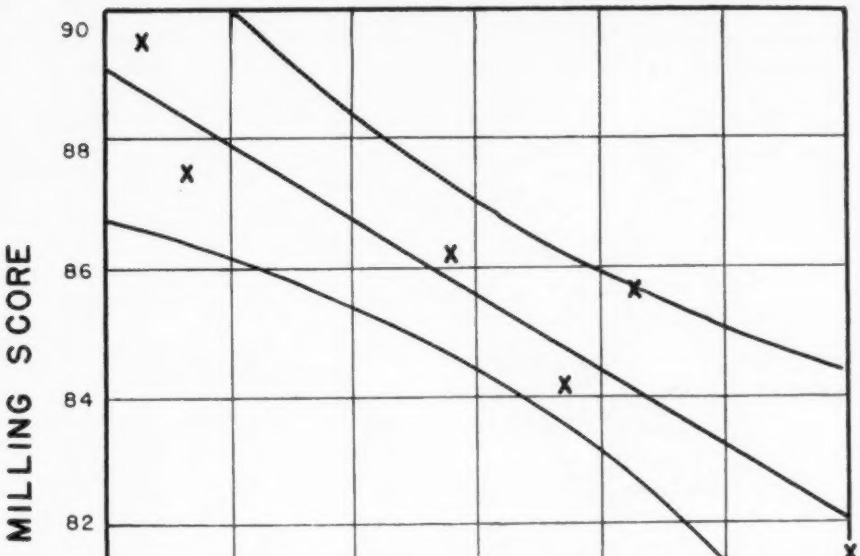

Fig. 3. Graph illustrating the relationship between milling scores and per cent weight increase of soaked kernels. Values on which the graph is based (1955 imbibition data and 1955 milling scores, Clarkan and Kawvale excluded) are given in Table III.

TABLE IV

PERCENT INCREASE IN WEIGHT OF SOAKED KERNELS—A COMPARISON OF THREE SERIES OF DATA.

Variety	1955 kernels, untreated	1956 kernels, untreated	1956 kernels, dried: actual values	1956 kernels, dried: actual values minus 12.3%
Blackhawk	54.7	54.8	66.1	53.8
Kawvale	62.8	60.9	72.7	60.4
Butler	......	58.5	72.2	59.9
Am. Banner	59.6	58.0	71.6	59.3
Wabash	55.1	55.7	66.9	54.6
Lucas	......	55.8	68.2	55.9
Thorne	61.4	60.0	72.4	60.1
Trumbull	62.6	59.8	73.2	60.9
Clarkan	57.5	56.4	66.4	54.1
Fairfield	66.0	61.7	74.7	62.4

tnen, that 1956 milling scores of Lucas and Butler varieties could not be predicted by using their 1956 imbibition percentages and Fig. 3, which is based on the relationship between 1955 imbibition data and 1955 milling scores. Indeed, 1956 milling scores are so unlike respective 1955 milling scores that no correlation between milling scores and imbibition percentages can be demonstrated if only 1956 data are analyzed.

To minimize effects of seasonal fluctuations in milling properties, one would have to compute the mean milling score of each variety for several seasons. Unfortunately, the Soft Wheat Quality Laboratory was able to supply only two sets of experimental scores in addition to those of 1955 and 1956 (Table V). One set of scores had been obtained by milling wheats which grew at Columbus in 1954. The other set was based on the milling properties of composite samples of 1953 wheats from New York State, Kentucky, and Michigan.

The average of the four milling scores for each variety (Table V) is perhaps the best estimate of the inherent milling quality of the variety which can be made at this time.

The average milling scores in Table V correlate negatively with both 1955 and 1956 imbibition data for untreated kernels, Clarkan and Kawvale data being excluded as before from the statistical calculations. Whether or not the single milling scores for Butler and Lucas are included as average milling scores, the correlation can be affirmed with greater than 95% confidence.

Discussion

Milling scores for 1955 wheats are negatively correlated with endosperm cell wall thicknesses (Part I) and with imbibition data. A positive correlation exists between imbibition data and endosperm cell wall thicknesses (Part I).

A reasonable explanation can be offered for these interrelationships between milling scores, cell wall thicknesses, and imbibition data. The thinner cell walls of some soft wheat varieties are easily torn during milling, permitting a higher flour yield with less milling time. Such varieties accordingly have higher milling scores than varieties with thicker endosperm cell walls. Also thicker cell walls would be expected to imbibe more water than thinner ones, unless samples were allowed to soak long enough for all parts of the kernels to become saturated. Perhaps this is why 24 hrs. soaking best reveals correlations of imbibition values with milling scores. During longer periods, increases in weight due to saturation of cell contents may obscure weight increases caused by diffusion of water into endosperm cell walls; shorter periods may

TABLE V

Comparison of available milling scores for experimental varieties.

Variety	1953 wheats, 3 sites	1954 wheats, Columbus	1955 wheats, Wooster	1956 wheats, Wooster	Average
Blackhawk	86.4	81.8	89.5	86.9	86.1
Kawvale	84.4	86.3	87.4	88.3	86.6
Butler				86.9	86.9
Am. Banner	85.0	81.5	86.2	86.5	84.8
Wabash	83.8	78.9	87.5	84.6	83.7
Lucas				84.3	84.3
Thorne	79.9	76.2	84.2	81.2	80.4
Trumbull	84.8	78.9	85.7	80.2	82.4
Clarkan	82.6	75.9	84.0	77.9	80.1
Fairfield	80.1	68.3	81.2	75.3	76.2

not permit maximum imbibition by endosperm cell walls.

Results of imbibition tests are somewhat more variable when kernels are dried before soaking, perhaps because the more rapid saturation of cell contents in heat-affected cells sometimes obscures the weight increase due to imbibition of water by endosperm cell walls. If oven-dried kernels had been soaked for less than 24 hrs., or if more replications had been made, the results might have been more closely correlated with milling scores than results obtained by soaking untreated kernels. However, on the basis of existing data, it can be stated only that imbibition percentages are more reliable when test kernels are not dried in an oven before soaking.

It must be emphasized that the experimental millings from which the milling scores in Table V were obtained were not performed on hand-picked kernels as the imbibition tests were. If a practical means had been available for removing damaged, diseased, and immature kernels from experimental milling samples, even higher correlations between imbibition data and milling scores might have been found.

Exclusion of data for Clarkan and Kawvale varieties from correlation calculations is justified on the basis of their hard wheat characteristics and ancestry. During the milling process, it has been reported that hard wheat is reduced to a somewhat gritty flour due to separation of endosperm cells *along* or adjacent to cell walls. Soft wheat is reduced to a more powdery flour, the endosperm being torn *across* cell walls (3). It is possible that the explanation for milling differences among hard wheats may involve the chemical composition of the middle lamella, rather than the thickness of endosperm cell walls.

Fig. 3 illustrates the method by which the 1955 milling score for a new variety of Ohio soft wheat could be predicted using 1955 imbibition data. Such a method is of no value, however, unless it can be used also to predict the general milling quality of a new wheat variety for many future crop years. Fig. 3 would serve that purpose only if neither imbibing properties nor milling scores were subject to seasonal variation. The similarity between 1955 and 1956 imbibition percentages suggest that imbibition differences are genetically controlled and that data obtained from one season's crop may express these differences adequately. In order to establish this inference more firmly, it will be necessary to perform imbibition tests on samples of wheat from more crop years. It is evident, however, that milling differences are related to the environment in which wheat grows as well as to genetic differences among varieties. If several experimental millings were made on samples from different crop years, and from different locations, it would be possible to compute an average milling score for each variety. Differences among these average milling scores, then, would reflect varietal rather than environmental differences. Assuming, as suggested before, that imbibition data vary little from season to season, one could set up a graph like that of Fig. 3, with imbibition percentages from any season as the abscissa and average milling scores as the ordinate. It would then be necessary only to perform imbibition tests on a newly developed soft wheat variety to predict its milling quality.

When the Seeborg formula is used to evaluate the milling quality of soft wheats, three difficulties are encountered: (1) Seeborg scores may vary more than 2.0 units from milling to milling, even when milled samples are of the same variety and are from the same site and season. (2) Since Seeborg scores vary from season to season, the milling quality of a new soft wheat variety cannot be established by Seeborg's method without

milling other soft wheat varieties from the same crop year and site for comparison. (3) A plant breeder must increase the first few grams of grain of a new variety until he has the 500 g. required for an experimental milling test. Predicting milling quality by means of an imbibition test would elminate the first two problems. Moreover, the imbibition test may be performed using less than 25 g. of kernels of a new variety, thus saving three to five years in the breeding program.

Summary

When kernels of 1955 crop samples were soaked in water for 24 hrs., the percentage weight increase due to imbibition was greater for poor milling wheats than for good milling wheats. The imbibition data from Clarkan and Kawvale, varieties known to have some hard wheat characteristics, were anomalous. Excluding these anomalous varieties, the statistical inference that for 1955 crop samples imbibition percentages and milling scores are correlated could be drawn with greater than 95% confidence. Poor milling wheats are believed to imbibe more water because of their thicker endosperm cell walls.

Imbibition percentages obtained from kernels of the same varieties in 1956 were sufficiently similar to 1955 values to indicate that imbibition differences are genetically controlled. Seeborg milling scores, however, are subject to considerable seasonal variation. It is proposed that an average milling score be computed for each variety from samples of grain from several crop years. A correlation has already been found between imbibition data and average milling scores of grain samples from four crop years. If this relationship is verified using data obtained from grain harvested in several additional crop years, imbibition data may be used to predict more accurately and easily the milling quality of new varieties of soft wheat, thus saving three to five years in the breeding program.

III. Resistance to Compression

Both milling time and yield of long patent flour are factors used ni calculating Seeborg (10) milling scores. This fact suggested the possibility that friability of the wheat kernel might be a varietal characteristic of soft wheats which is indirectly but positively correlated with milling quality. Preliminary experiments employing both indirect and direct methods of assessing friabilty of kernels were conducted. The technique which seemed to offer the most promise was one in which a force necessary to produce the initial cracking of the kernel is measured quantitatively.

Materials and Methods

Samples of seven varieties of soft wheat from the 1955 crop (American Banner, Blackhawk, Clarkan, Fairfield, Thorne, Trumbull, and Wabash) and one variety (Kawvale) which has been classified as a hard wheat (1) were used. In addition, samples of ten varieties from the 1956 and 1957 crops, including those mentioned above plus Lucas and Butler, were used. The samples and Seeborg milling scores for each were obtained from the U.S.D.A. Soft Wheat Quality Laboratory at the Ohio Agricultural Experiment Station, Wooster, Ohio where the wheat grew. Small, damaged, and otherwise obviously imperfect kernels were discarded. Kernels which were to be oven-dried were placed in glass vials at the outset. The vials remained closed after drying, except while kernels were being removed, in order to prevent imbibition of water vapor from the atmosphere by the kernels. Kernels were removed from the vials with a forceps.

A Karol-Warner unconfined compres-

sion machine, manufactured by the Tinius Olsen Testing Machine Co., Easton Road, Willow Grove, Pa., was used for testing the kernels. Each kernel was placed, crease down, in the center of the lower sample head of the machine. The upper sample head, with a force gauge attached, was lowered to just above the kernel. A motor-driven mechanism raised the lower sample head at a constant speed of 0.04 inch per minute. Maximum force at the time of the first crack of the kernel was recorded. After the ten kernels had been tested one at a time, the lower sample head was lowered to the starting level. Five replicate samples of ten kernels each for each year and drying treatment were tested at random. Compression values of the fifty kernels were then averaged and this average value was used in making various varietal comparisons.

Results and Discussion

Some difficulty in obtaining precise readings from the dial indicator on the machine was encountered in initial tests in which untreated kernels were used. Usually a series of three readings was obtained for each kernel. As the kernel was subjected to increasing force, the first reading was followed by a series of momentary time lapses alternating with advances and/or recessions of the dial indicator needle. It was inferred that the kernel was undergoing a type of crushing action indicative of a semi-plastic object. In an effort to obtain a measure of friability, samples of wheat were dried in an oven at 55°C. for 3½, 7 and 14 days. When a kernel, which had been dried for 7 or 14 days, was tested, the needle of the dial indicator gradually advanced to a peak reading then receded rapidly to near zero. No further advances of the needle occurred unless a relatively long time elapsed after which the fractured pieces of the kernel were elevated on the lower sample head and finally were compressed against the upper sample head. Because of the convenience of precise dial reading and because it seemed that a quick fracturing of the kernel rather than a crushing action was obtained, kernel samples for further testing were first dried in an oven. In general, drying kernels for 7 days at 55°C. seems to result in about a 10% increase in machine test values and an additional 7 days of drying seems to result in additional hardening not exceeding 10% of the original value. For instance, undried kernels of Fairfield had a test value of 16.7 machine units. Kernels dried for 3½, 7, and 14 days at 55°C. gave test values of 17.0, 18.5, and 19.2 machine units. The real advantage of drying, however, is a perceptible increase in uniformity of kernel test values for each variety.

Very few, if any, embryos of kernels dried for as long as 2 weeks at 55°C. were killed by the treatment. In tests conducted in March, 1958 we found that 82% or more of the dried kernels of each 1955 crop varietal sample germinated when placed in a suitable environment.

Compression force values given in machine units for ten varieties from three crop years are recorded in Table VI. These values were obtained during the first five months of 1958. It is obvious, therefore, that samples from the various crop years were tested after different periods of time had elapsed following harvest. If the time interval between date of harvest and date of performance of Seeborg Test milling and compression tests were uniform for each variety for each of several crop years, the effect of time on kernel hardness and on milling score could be determined. It is possible that the unavoidable failure to control the time factor in testing may account for the progressive decrease in compression force values from the 1955 to the 1957 crop samples for each variety and drying time. Only four exceptions to this general trend are found in Table VI. An *increase* in compression force values for samples of

TABLE VI

MEAN COMPRESSION FORCE VALUES IN MACHINE UNITS[a] FOR 50 KERNELS DRIED ONE AND TWO WEEKS AT 55°C.

Variety	1955 Crop 1 wk.	1955 Crop 2 wks.	1956 Crop 1 wk.	1956 Crop 2 wks.	1957 Crop 1 wk.	1957 Crop 2 wks.	Average of Crops 1955, 1956, 1957 1 wk.	Average of Crops 1955, 1956, 1957 2 wks.
Blackhawk	22.00	21.50	17.66	16.98	16.06	16.26	18.57	18.25
Kawvale	25.06	24.56	19.54	21.62	17.70	19.04	20.77	21.74
Butler	......	......	15.72	17.04	15.40	16.00	15.56	16.52
Am. Banner	19.92	21.68	13.82	14.54	12.64	13.10	15.46	16.44
Wabash	22.70	23.06	16.22	15.94	15.22	15.68	18.05	18.23
Lucas	......	......	16.50	17.20	16.40	17.98	16.45	17.59
Thorne	19.26	21.36	14.14	14.24	13.00	13.84	15.47	16.48
Trumbull	21.12	21.60	13.70	13.28	13.86	13.72	16.23	16.20
Clarkan	22.56	22.94	20.94	20.36	17.26	18.08	20.25	20.46
Fairfield	18.50	19.16	13.04	12.72	12.56	12.98	14.70	14.95

[a]Scale: 1 machine unit equals 0.828 pound; 1 pound equals 1.208 units.

Lucas, Trumbull, and Fairfield dried two weeks and for samples of Trumbull dried one week may be noted when comparing data for the 1956 crop with those for the 1957 crop (Table VI). This progressive increase in hardness with the time following harvest appears to be accompanied, in general, by progressively higher milling scores (Table VII, data for 1955, 1956, 1957 crops). This progressive increase in hardness may be the result of a decrease in moisture content of the grain. However, since all kernels were dried for either one or two weeks at 55°C., it seems rather doubtful that moisture content of the samples would vary greatly.

Let us consider now the effects of this variable in terms of our objective to use compression force values as reliable indices of varietal milling quality. It is certainly unreasonable to expect that each of the three compression values for each of the two drying times (Table VI) should correspond to one specific milling score value for the variety in question. Essentially we would be attempting to equate two series of values with a single varietal milling score. Furthermore, two of the three compression force values in the same series may differ by more than 60 per cent of the lower value (Table VI, American Banner dried two weeks).

If we consider the matter of Seeborg milling scores as indicators of milling quality, we are confronted with another variable of considerable magnitude. Now, if we allow that milling quality of a variety is primarily a reflection of its heredity,

TABLE VII

SEEBORG MILLING SCORES FOR TEN VARIETIES OF WHEAT AT VARIOUS LOCATIONS IN FIVE CROP YEARS.

Variety	1953 3 sites[a]	1954 Columbus	1955 Wooster	1956 Wooster	1957 Wooster	5 year Mean Milling Score
Blackhawk	86.4	81.8	89.5	86.9	87.4	86.40
Kawvale	84.4	86.3	87.4	88.3	88.1	86.90
Butler	......	......	......	86.9	83.6	85.25
Am. Banner	85.0	81.5	86.2	86.5	85.6	84.96
Wabash	83.8	78.9	87.5	84.6	83.9	83.74
Lucas	......	......	......	84.3	84.0	84.15
Thorne	79.9	76.2	84.2	81.2	79.2	80.14
Trumbull	84.8	78.9	85.7	80.2	84.1	82.74
Clarkan	82.6	75.9	84.0	77.9	78.2	79.72
Fairfield	80.1	68.3	81.2	75.3	75.6	76.10

[a]Milling properties of composite samples of 1953 wheats from New York, Kentucky, and Michigan.

TABLE VIII

COMPARISON OF RANKS BASED ON SEEBORG MILLING SCORES AND COMPRESSION FORCE VALUES FOR CROP YEARS WHEN SAMPLES OF TEN VARIETIES WERE AVAILABLE.

Variety	Milling Score Rank[a] 1956	Milling Score Rank[a] 1957	Compression Force Value Rank[b] 1956	Compression Force Value Rank[b] 1957
Blackhawk	2	2	5	4
Kawvale	1	1	1	1
Butler	2	7	4	5
Am. Banner	4	3	7	9
Wabash	5	6	6	6
Lucas	6	5	3	3
Thorne	7	8	8	7
Trumbull	8	4	9	8
Clarkan	9	9	2	2
Fairfield	10	10	10	10

[a]From Table VII.
[b]From Table VI, for kernels dried 2 weeks at 55°C.

then any test for milling quality should result in very similar values for test samples of that variety regardless of crop site or crop year. But if we examine milling scores for ten varieties of wheat which grew at various locations in five crop years, we see that year and site differences in the scores for the same variety are, in some instances (Fairfield 1954 vs. 1955), greater than differences between the highest and lowest scoring of all ten varieties in the same year (Table VII, 1954, 1956, 1957). This means that milling score *rank* is not consistent from year to year (Table VIII). Milling scores of Butler, for example, rank it second in 1956 and seventh in 1957 among the ten varieties being considered. Milling scores of Trumbull place it eighth in 1956 and fourth in 1957. It is rather obvious then, that the Seeborg score obtained by milling a sample of wheat from a given site and crop year is not a reliable index of milling quality of eastern soft wheats. Furthermore, we should not expect significant correlation to exist between compression force values and milling scores obtained from samples of varieties from the same site and crop year. Evidence for this lack of significant correlation is found in Table IX.

An effort was made to minimize the

TABLE IX

DEGREE OF CORRELATION OF MEAN COMPRESSION FORCE VALUES FOR VARIOUS TREATMENTS AND YEARS WITH SEEBORG MILLING SCORES FROM THE RESPECTIVE YEARS, INCLUDING AND EXCLUDING VARIETY CLARKAN. (FOR COMPRESSION FORCE VALUES AND SEEBORG SCORES, SEE TABLES VI AND VII).

Year	Drying time at 55°C.	Number of varieties tested	Correlation coefficient	Significance Values[a]
1955	1 week	8	0.6337	......
Crop	2 weeks	8	0.5737	......
1956	1 week	10	0.5872	......
Crop	2 weeks	10	0.6248	......
1957	1 week	10	0.4610	......
Crop	2 weeks	10	0.5454	......
Degree of Correlation excluding var. Clarkan				
1955	1 week	7	0.7380	......
Crop	2 weeks	7	0.6860	......
1956	1 week	9	0.7435	0.05
Crop	2 weeks	9	0.7796	0.05
1957	1 week	9	0.6541	......
Crop	2 weeks	9	0.5901	......

[a]Values from Snedecor (11).

effect of these two variables and to ascertain whether any significant correlations exist between compression forces and milling scores. Five year mean milling scores were calculated for each variety (Table VII). Statistically significant correlations were then sought, omitting data for Clarkan. The anomalous position of Clarkan in the compression force tables VII and VIII is not surprising since it has some hard wheat characteristics, probably due to hard wheat ancestry (1, 4).

Compression force values of wheats from three individual crop years (1955, 1956, and 1957) correlate significantly with five-year mean milling scores at the 5% level if kernels are dried either one or two weeks and the data for Clarkan are omitted. There is one exception. Although compression force values of 1957 wheat dried two weeks do not correlate to a 5% level with their five year milling scores, the 5% level (P = 0.666) is very closely approached (Table X).

It would therefore appear that the compression force test which is relative quickly and easily performed with simple apparatus and a small number of kernels (50) can be made the basis for a reliable soft wheat quality testing procedure.

Summary

Resistance to compression force of eight soft wheats and two semi-hard wheats was measured quantitatively in an effort to obtain data which might be correlated with milling quality. A progressive increase in kernel hardness with time following harvest appears to be accompanied, in general, by progressively higher milling scores for wheats growing at the same site. Compression force values of soft wheats from the 1955 crop, from the 1956 crop, and from the 1957 crop correlate to a 5% level with five year mean milling scores if kernels are dried for one week at 55°C. It would therefore appear that the compression force test which is relatively quickly and easily performed with simple apparatus and a small number of kernels (50) can be made the basis for a reliable soft wheat quality testing procedure.

The Seeborg milling score obtained by milling a sample of wheat from a given site and crop year appears to be an unreliable index of milling quality of eastern soft wheats.

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TABLE X

Degree of correlation of mean compression force values for wheats of different crop years dried one and two weeks with a five year mean milling score. (From Table VII). Data of Clarkan were excluded from calculations.

Year	No. of varieties tested	Correlation coefficient 1 wk.	Correlation coefficient 2 wks.	Significance Values[a] 1 wk.	Significance Values[a] 2 wks.
1955	7	0.7875	0.7906	5% (P = 0.754)	5% (P = 0.754)
1956	9	0.7423	0.7452	5% (P = 0.666)	5% (P = 0.666)
1957	9	0.6908	0.6598	5% (P = 0.666)	———

[a]Values from Snedecor (11).

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Brush and Filling Fibers from Bamboo

ROBERT E. PERDUE, JR., CHARLES J. KRAEBEL,
and CHI-WEI YANG[1]

Bamboo fiber is a crude product prepared by crushing and shredding short sections split from bamboo culms. The fiber is coarse and is formed of individual or small groups of vascular bundles. It is very flexible and lacks strength. Large quantities of this fiber are produced in small mills in Taiwan (Formosa) for local use. The mill described herein is typical of fiber mills in that country as to size, methods employed, and amount of production.

Taiwan mills use all available species of bamboo for production of fiber without preference for any single species. The mill described and illustrated was using *Bambusa dolichoclada* Hayata at the time the accompanying photographs were taken.

Culms used for fiber must be processed within a week after they are cut and must contain at least 40% moisture. Those in the first or second year of growth are

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Fig. 1. Crusher used to crush short split sections of bamboo culms prior to shredding. (U.S.D.A. Photo, Neg. No. 94747).

Fig. 2. Feeding split sections of bamboo into the crusher. (U.S.D.A. Photo, Neg. No. 94746).

preferred. Older culms and those which have been allowed to dry out are difficult to process and yield an inferior product.

The culms are cut with a circular saw into lengths of 2 feet. These short lengths are split into quarter- or third-sections with a stout-bladed machete-like knife. The split sections are tied in bundles about 8 inches in diameter with a single short length of rice-straw rope.

The culm sections are passed through two electric-motor-powered crushers (Fig. 1-2) manned by four workers. Each of the two crushing units consists of four pairs of fluted rollers about 6 inches in diameter. The lower four rollers are fixed; the upper four rollers can move up or down but are forced against the lower rollers by heavy-duty springs.

The first operator unties the bundles and inserts the culm sections between the first set of rollers. As they emerge from the opposite end of the crusher, a second operator places the crushed bamboo on the top of the upper rollers, which return the crushed sections to the first operator. The sections are again passed through the crusher. Before feeding a new bundle of

culm sections to the crusher the first operator thumps the machine sharply with the first piece of bamboo as a signal to the second operator. After the second pass through the crusher the second operator places the crushed strips on a platform beside the first operator of the second crusher.

Some of the bamboo strips are crushed satisfactorily after a single pass through the second crusher and are set aside as they emerge from the rollers. Others are returned to the head of the machine for a second pass through the rollers. The thoroughly crushed bamboo is carried to a counter adjacent to the shredder.

The shredder (Fig. 3) is constructed of oak boards, 1 by 4 inches by 8 feet, bolted at each end to two wooden disks centrally attached to a shaft. The unit forms a drum about 2 feet in diameter. Very sharply pointed spikes about the size of a 10d nail project 1 inch from the boards at four different positions. At each position 12 straight rows of spikes are set around the drum with a space of about ¾ inch between rows. The drum is powered by an electric motor and revolves very rapidly.

The shredder is operated by as many as four workers (Fig. 4). The worker selects a small handful of crushed bamboo strips about 2 inches in diameter and, holding one end, presses the opposite end of the bundle down on the spikes of the revolving drum. The worker turns the bundle several times to insure that all the strips are completely shredded, then reverses the position of the bundle to shred the opposite ends of the strips. As the sharp spikes tear the crushed bamboo apart, a portion of the material is pulled away as loose fiber and collects in front of the shredding drum. When a sufficient amount of this fiber has accumulated it is baled.

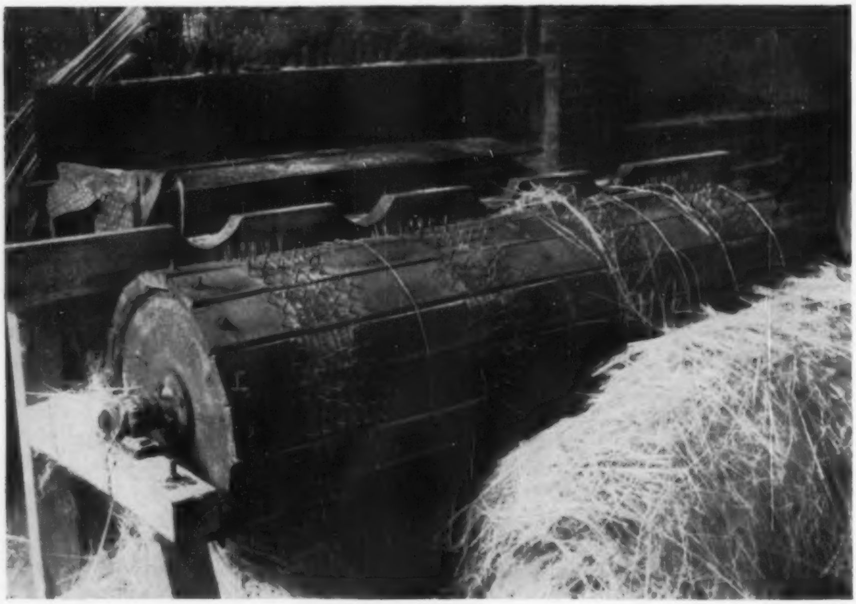

Fig. 3. Shredding drum. (U.S.D.A. Photo, Neg. No. 94750).

Fig. 4. Shredding crushed sections of bamboo culms. (U.S.D.A. Photo, Neg. No. 94749).

The shredded bundles of bamboo are stacked in neat piles. This coarse fiber is baled in 220-lb. lots (Fig. 5). The fiber may be moist when baled and, with prolonged storage, the interior of such bales may heat and decay.

The mill described herein employs ten workers and produces 3 tons of fiber per day. Wages amount to NT \$400[2] per month for women and NT \$600 per month for men. There are about 13 bamboo-fiber mills in Taiwan. They produce a total of 7,500 tons of fiber per year.

Coarse bamboo fiber is traditionally used for making brushes and brooms. The fine fiber is used as a filling material for mattresses and pillows and as an abrasive swab for cleaning the decks of ships. Both types of fiber are used as an emergency raw material by a small but modern paper mill when bamboo culms are not available. This mill manufactures writing and printing papers. The mill

[2]NT \$36 = U. S. \$1.

Fig. 5. Chi-Wei Yang (right) and fiber-mill operator by bales of coarse bamboo fiber. (U.S.D.A. Photo, Neg. No. 94751).

pays NT $350 per ton for bamboo fiber and NT $225 per ton for bamboo culms, chiefly *Phyllostachys makinoi* Hayata. The greater cost of the bamboo fiber is offset to a large extent by its lower caustic requirement during pulping, lower chlorine requirement during bleaching, and higher yield of stronger pulp. The paper mill uses as much as 2000 tons of bamboo fiber during a year.

Bamboo Mechanical Pulp for Manufacture of Chinese Ceremonial Paper

ROBERT E. PERDUE, JR., CHARLES J. KRAEBEL, and TAO KIANG[1]

Bamboo is an important raw material for manufacture of paper pulp in areas where it is abundant, especially in India, Pakistan, Taiwan (Formosa), and mainland China. In most instances it is reduced to pulp by chemical treatment under pressure at high temperature. An exception is the manufacture of bamboo mechanical pulp in Taiwan. This pulp is combined with a small amount of rice-straw chemical pulp for manufacture of a product used to prepare the so-called "joss paper" employed in Chinese religious and funeral ceremonies. "Joss" is a pidgin English word that is derived from the Portuguese *deos* or *deus,* god, and is used to refer to a Chinese household divinity or to a cult image.

Joss paper consists of sheets of crude paper of various sizes, mostly 2½ by 3 inches, to 10 by 11 inches, usually almost completely or partially covered with a piece of tin foil. A golden metallic effect is created, according to Hunter,[2] by brushing the foil with seaweed extract containing a dye extracted from flowers of *Sophora japonica* L. The paper is commonly wood-block printed in red ink with a design of religious significance (Fig. 1). The term "joss paper," when used in a broader concept, is applied also to crude paper disks cut to resemble coins.

Although certain forms of joss paper might best be described as offerings to be burned at religious ceremonies, most forms are intended to imitate money. This mock money is ceremoniously burned at funerals or at rituals honoring long-departed friends and relatives. The foil-covered sheets may be folded to represent nuggets of gold or silver. Thus, money is sent to the deceased so that he can buy the necessities of "life" and, perhaps,

Fig. 1. This is a facsimile of the design printed on a modern sheet of Chinese ceremonial paper. The design is printed in a shade of red. In China this color is symbolic of good fortune. The three figures represent the gods of long life, health, and wealth.

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[2]Some of our comments, especially those relating to the uses of joss paper are based on Dard Hunter's "Chinese Ceremonial Paper. A Monograph Relating to the Fabrication of Paper and Tin Foil and the Use of Paper in Chinese Rites and Religious Ceremonies." Mountain House Press. Copyright by the Author. 1937. Many and varied samples of ceremonial papers are bound into this book. The book was published in a very small edition. A copy is available in the rare book collection of the Library of Congress, Washington, D. C.

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some of the luxuries denied to him on earth.

The burning of ceremonial papers is a national practice of the Chinese. Although the paper is employed in the course of religious ceremonies, its use neither is associated with a single religion nor extends to non-Chinese peoples who practice the religions of China.

Paper used for the preparation of joss paper is now machine-made in four small mills in Taiwan. The oldest of these mills, the Kungchin Mill, located at Feng-yüan in T'ai-chung Hsien, is described herein. Kungchin Mill, established in 1914, produces about 2 tons of this paper per day. The mill also produces wrapping and bag papers from rice straw and bagasse.

The total production of ceremonial paper in Taiwan is estimated to be about 4,500 to 5,000 tons per year. A large proportion of this is handmade in some 500 small paper mills in the three *hsien* of Chia-yi, Hsin-chu, and Nan-t'ou.

Bamboo is the traditional raw material for the manufacture of the sheets used to prepare joss paper. On the Chinese mainland *Phyllostachys pubescens* Mazel ex H. de Leh. (*P. edulis* H. de Leh.) was, according to Hunter, the most commonly used species. Kungchin Mill most commonly uses *Bambusa stenostachya* Hackel, *Dendrocalamus latiflorus* Munro, or *Bambusa oldhamii* Munro (*Leleba oldhamii* [Munro] Nakai). This mill also uses a small amount of rice-straw pulp. Straw is pulped in a rotary digester with 16% caustic soda. The straw-loaded digester is rotated for 1 hour at 80-pounds pressure and then allowed to stand for 2 hours before the pulp is discharged.

Newly harvested green bamboo culms received at the mill can be used immediately but dry culms must be soaked in water before use. Large concrete water tanks are employed for storage of culms and for soaking long-harvested dry culms. Pulp ground from green or water-softened culms produces a stronger and finer-textured paper that is more easily dyed than that produced from seasoned culms.

The culms are first cut into 2-foot lengths with a circular saw. These pieces are separated into two groups according to diameter. The smaller sizes are preferable because a larger charge of these (weight basis) can be placed in the grinder.

The bamboo is mechanically reduced to a pulp in a 2-pocket, hydraulic-feed, hand-loaded grinder (Fig. 2). The grindstone weighs about 1.5 tons and is cut from granite originating at Shui-li-kêng near Sun-Moon Lake. The mill pays NT $3000[3] for cutting of the stone and NT $1000 for transport and other costs. Each stone has a life of about 1 year but must be resurfaced every 60 days with a power-driven hardened-steel wheel.

The grinder is operated and charged by a single worker. About 5 pounds of rice-straw pulp are placed in the pocket of the grinder and the pocket is then filled with the 2-foot lengths of bamboo. When a control lever is adjusted, hydraulic pressure is applied to a plunger which forces the pulp and bamboo against the rapidly turning grindstone. When the charge has been ground, an adjustment of the control lever automatically raises the plunger and opens the pocket for a new charge. Water is applied to the stone during the grinding operation to reduce friction. The water-pulp mixture flows from the base of the grinder into a trough. This slush pulp moves through the mill by gravity flow through crude wooden open or covered troughs.

Slush pulp from the grinder flows to a flat vibrating screen for separation of acceptable fiber from poorly ground material. This screen, perforated with circular openings ⅜ inch in diameter and about ½ inch apart, vibrates vigorously in both the vertical and the horizontal planes. Acceptable fiber passes through

[3]NT $36 = U. S. $1.

Fig. 2. Grinder used to prepare bamboo mechanical pulp. (U. S. Department of Agriculture photo, Neg. No. 94752).

the screen. Clumps of inadequately ground bamboo, too large to pass the perforations, are scraped off the screen by a series of metal bars attached at each end to two belts which turn over pulleys above each end of the screen. These rejects are returned to the grinder and reground.

The screened pulp flows to one of three settling tanks. A tank is filled and then allowed to overflow at the opposite end. The fiber settles to the bottom of the tank as the water overflows. This method of concentration is continued until the pulp reaches a consistency suitable for formation on the machine. When the pulp in the settling tank reaches the desired consistency, it is drained into a mixing tank. Here, a yellow dye is added to pulp intended for formation of the best-quality paper.

From the mixing tank the pulp flows directly to the flow box of a very primitive-type cylinder paper-machine (Fig 3). The cylinder is about 3 feet in diameter. The flow box is relatively shallow; its upper level is slightly lower than the upper level of the cylinder. The cylinder

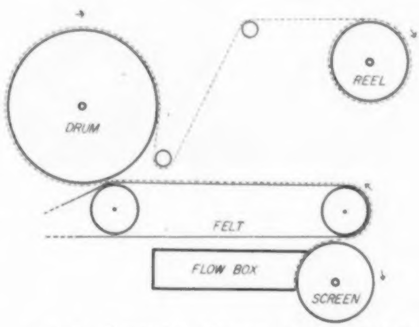

Fig. 3. Simplified diagram of the machine used at Kungchin Mill for making ceremonial paper.

end of the flow box is contoured to fit closely to the surface of the cylinder wire; that is, the drum closes one end of the flow box; pulp flows into and across the box directly to the wire. As water flows through the screen and drains away at one end of the cylinder, a film of fiber is deposited on the screen.

The pulp mat deposited on the cylinder as the latter revolves is picked up by a felt and returned above the machine to a large steam-heated drying drum 6 feet in diameter. Water is sprayed on the screen of the cylinder to remove any fiber not picked up by the felt. The mill operates two of these machines, each at a speed of 100 to 110 feet per minute and capable of a maximum production of 1.5 tons of paper per day. Production must be stopped frequently so that the cylinder wire can be cleaned with water from a high-pressure hose. When the screen becomes dirty, large holes appear in the paper.

Fig. 4. Ceremonial paper produced at Kungchin Mill, tied with rice-straw rope and ready for delivery. (U. S. Department of Agriculture photo, Neg. No. 94755).

The cylinder forms a continuous sheet about 4 feet wide. This is split into two narrower strips as it reaches the drying drum. From the drum the dry paper passes to a wooden reel about 8 feet in circumference. About every 3 minutes the paper collected on the reel is removed by cutting through all the layers at a single point and collecting the 2 by 8 feet sheets. The paper is then cut into sheets of uniform size according to the order of the buyer. A typical order calls for sheets 6 x 24 inches. The paper is inspected and damaged sheets are removed. Many are torn or have large holes. The paper is packed in 110 pound bales and tied with rice-straw rope (Fig. 4). The mill receives about NT $170 per bale.

Kungchin mill produces two grades of bamboo "groundwood" paper. Pulp for the cheaper grade is ground more rapidly than that for the better grade paper. The cheaper grade is thicker and coarser than the better grade and contains little or no yellow dye. Both grades are very weak, but for the purpose for which they are intended no strength is needed.

At present, most of the groundwood paper produced by Kungchin Mill is being used in Taiwan. A small amount is exported to Thailand and small quantities reach overseas Chinese communities in Asia and possibly in western nations. Some paper of this type probably reaches the international market from mainland China through Hong Kong.

The Rice-Paper Plant—*Tetrapanax* Papyriferum (Hook.) Koch

ROBERT E. PERDUE, JR.[1] and CHARLES J. KRAEBEL[2]

Introduction

Rice paper is a soft velvety paper-like substance, long used in North America and Europe as a raw material for making very realistic artificial flowers. It has also been used for many years by Chinese artists as a surface for water colors.

In two respects rice paper was very inappropriately named. Rice plays no part either in its origin or in its manufacture. In the generally accepted sense that paper consists of matted fibrous matter rice paper is not a true paper. The product is prepared from the spongy pith of an Asiatic plant, *Tetrapanax papyriferum* (Hook.) Koch. The origin of the name "rice paper" is unknown but it probably arose through the misunderstanding of early western explorers of the Orient; rice paper was believed by laymen to have been prepared from rice straw. Early botanists who examined the product were readily aware that it was not produced from a grass but could offer little more than an indication that it came from a dictoyledon.

From time to time during the first part of the 19th century the paper was suspected of being derived from the breadfruit tree (*Artocarpus altilis* [Parkins.] Fosberg) (4, 8) or from the "shola" (*Aeschynomene aspera* L.) (14, 27).

Botany

History. The rice-paper plant was first mentioned in western literature in Rumphius' "Herbarium Amboinense" (33) published in 1690. Under a description of *Buglossum litoreum,* the "moral" of Amboina, Rumphius appended notes on the utilization of a plant that, judging from its uses, must be identified as *Aeschynomene aspera*. The pith of this species of *Aeschynomene* was used for the fabrication of the pith helmet in India and for the fabrication of artificial flowers in India, Siam, and Malaya. Rumphius referred to the "Chinese kind" from the "northern coast of Formosa," not "in China proper," alluding to the rice-paper plant. His information was apparently based on hearsay. *"Buglossum litoreum"* is *Scaevola frutescens* (Mill.) Krause, a species of Goodeniaceae (30). Rumphius thus confused the uses of two different plants with a third plant that he described.

In 1727, in a letter written in Peking and addressed to his superior in Paris, a French missionary, d'Entrecolles (11), gave a reasonably accurate account of the rice-paper plant and its use by the Chinese. Citing a Chinese herbal, he correctly noted the plant's resemblance to the "riccin" or "palma christi" (*Riccinus communis* L.). This letter was published in a collection of similar letters in 1838 but apparently never came to the attention of the 19th century botanists who were concerned with the identity of the rice-paper plant.

Rice paper was first brought to England by a Dr. Livingstone about 1805 (14). The product became well known but remained a curiosity of unknown origin until its identity was more or less definitely established by W. J. Hooker in 1852 (17). In an effort to establish

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Fig. 1. Illustration of Tetrapanax papyriferum in Bennett's "Wanderings in New South Wales . . ." 1834 (3).

the identity of the plant, Hooker requested information about it from a General Hardwicke, then resident in the East Indies. Hardwicke believed the source of rice paper to be the same as that of the "shola" (*Aeschynomene aspera*) of India. His excellent description of that plant and its utilization was published by Hooker (14) without questioning the authenticity of the identification[3].

In 1834, Bennett, in his "Wanderings in New South Wales . . ." (3) published a figure of the rice-paper plant (Fig.1), adapted from a large colored drawing by a Chinese artist that he had obtained in Canton (4). This was a true representation of the plant and was apparently the first picture of the plant available to the western world although a figure had been published earlier in the work of Li-shi-chin (29). Hooker did not see Bennett's figure until 1853 (19) and as far as can be determined from the literature it was not seen before by any other competent botanist. Bennett did state later that the woodcut in his "Wanderings" was shown to A. B. Lambert and David Don, who suspected that it would prove to be an *Aralia* (5).

About 1850, Hooker received from J. H. Layton, British consul at Amoy, samples of the pith, a model of the knife used in cutting the paper, information on the source (Formosa) of the rice paper, and a description of the manner of preparation (15). He then realized from a comparison of the two materials that rice paper and "shola" were not products of the same species.

Later in 1850 Hooker examined a set of 11 paintings (Fig. 2) brought from China by a traveler, C. J. Braine, reputedly illustrating all phases of cultivation of the rice paper plant and the production of rice paper (16). An additional figure had been obtained in China by J. Reeves, this too, reputedly representing the rice-paper plant. This figure had been made by a Chinese artist from a plant growing in Reeves' garden. From Reeves' picture botanists assumed that the plant was a member of either the Araliaceae or Malvaceae. Reeves' picture did not show more than a shade of resemblance to Braine's paintings. Hooker was inclined to doubt the authenticity of Reeves' picture as it was prepared by a Chinese at Reeves' request, whereas Braine's pictures had been prepared spontaneously without promise of remuneration. Hooker assumed that Braine's pictures were authentic but did recognize that the size of the stems was out of proportion.

Seeman, in 1852 (34), published a brief account of his efforts in China to obtain information leading to the identity of the source plant. He was able to obtain samples of the pith but only con-

[3]The rice-paper plant was again confused with *Aeschynomene aspera* by Lewis in 1852 (27). Lewis confused the plant with the species used by the Malays and Siamese in the fabrication of artificial flowers. He had first-hand knowledge of the plant and its uses and identified it as "*Scaevola Taccada* of Roxburg." From information obtained from his Chinese neighbors about the Formosan plant and from a comparison of "Scaevola" pith with a sample of rice paper, he assumed that the two source plants were the same.

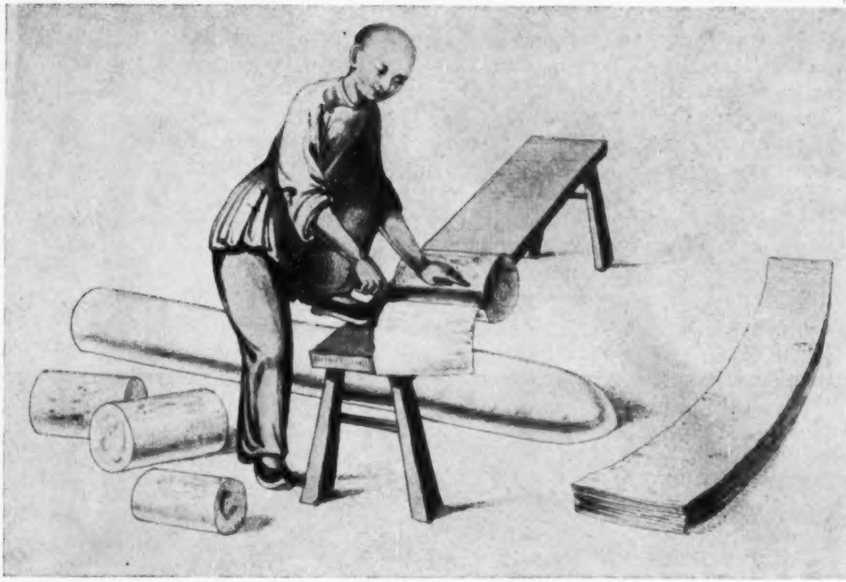

Fig. 2. Reproduction from the Journal of Botany (16), reputedly representing the rice-paper plant. The artist's imaginative portrayal was reasonably accurate in principle if not in fact. Compare Fig. 6.

flicting information about the plant. From descriptive information obtained from a translation of a portion of the work of Li-shi-chin (29) and a woodcut contained in the latter, he supposed the plant to be a member of the Malvaceae.

About this time Mrs. Layton, widow of the former British consul at Amoy, forwarded a living plant to Hooker. Although the plant died enroute, the remains—root, stem and partly decayed leaves— were received by Hooker. A microscopic comparison of a section of the stem with a sample of rice paper convinced him that the plant was the source of this product. The remains of the leaves were sufficient to identify this plant as the same species as that represented in the picture obtained by Reeves some years earlier. Although flowers and fruit were completely unknown and Hooker had seen neither a living specimen nor an herbarium specimen in a reasonable state of preservation, he was certain that the plant was a species of Araliaceae and suspected that it was a member of the genus *Aralia*. He described the plant at this time as *Aralia ? papyrifera* and illustrated it with a reproduction of the Reeves picture, diagrams of the stem and root, and a microscopic diagram of the pith (17).

Later in 1852, two living plants sent by J. W. Bowring were received at Kew (18) and in 1855 Hooker noted receipt of flowering specimens from Bowring (20, 21).

The plant supplied by Bowring flowered in England in 1855. The flowers dropped off as rapidly as they formed. With this material and the dried flowering specimens received earlier, Hooker was able to prepare a complete description of the plant and published this with

a figure illustrating flowering racemes and details of flowers and fruit in Curtis's Botanical Magazine (22). The plant was provisionally retained in *Aralia*.

Taxonomy. The rice-paper plant, described first by Hooker in 1852 (17) and later recharacterized by him (22) in 1856 as *Aralia papyrifera*, was transferred to *Didymopanax* as subgenus *Tetrapanax* by Koch in 1859 (25). Koch, a short time later, elevated the subgenus to generic rank (26). Bentham and Hooker f. (6) regarded the plant as a species of *Fatsia*; however, the disposition made by Koch has been the most widely accepted and the plant is best known today as *Tetrapana papyriferum* (Hook.) Koch, the only species of this genus.

Common names. In the West the plant is generally known under the name of "rice-paper plant" or by terms representing literal translations of that phrase. In China and Formosa the plant is known as "bok-shung" (15) or "tung-tsao." The latter name, variously spelled "tung-tsaou," "tung-tsau," "tong-tsao," "thong-

Fig. 3. Tetrapanax papyriferum along a roadside between Shui-li and Chi-chi in west-central Formosa. (U.S.D.A. Photo, Neg. No. 94759).

chow," or "toong-shue," when written in western style, is best translated as "permeable plant." "Tung" literally means "passing through." In Japan the plant is called "tsuso" or "shin-tung-tsao" (35). In the United States, rice paper is sold on the retail market as "wood fiber."

Description. Under natural conditions *Tetrapanax papyriferum* is usually a shrub three to six feet tall (Fig. 3) but may attain a height as great as thirty feet. When maintained as an ornamental the plant commonly attains heights of nine to fifteen feet and may be described as a small tree. The main stem of fully grown plants is usually two to three or at most four inches in diameter. It is commonly crooked and branches, often divergently, three to six feet above the ground to such an extent that the crown may attain a diameter of six to twelve feet. The bark is rough and the wood hard and heavy.

The pith of young plants is snowy white, becoming creamy-colored or brownish with age, and may be up to two inches in diameter. When dry, it has a density of approximately two pounds per cubic foot (approximately .03 g per cm^3). Fresh pith contains about 60% moisture (31). The lower extension of the pith is commonly septate; the upper portions are septate or solid. The pith attains its greatest diameter in the upper part of the main trunk. According to Hahne (13), pith up to three years old is solid; after that a diaphragm-like septation occurs at the core.

The evergreen chartaceous to subcoriaceous leaves are large, up to two feet long, and are borne on long petioles up to 2.5 feet long and one inch in diameter. They are cordate and palmately seven to twelve lobed with deep sinuses; the lobes are acute and serrate. The leaves are glabrous above (at least when fully developed) and densely tomentose below with stellate ferruginous hairs. The petioles and the portion of the stem adjacent to the point of attachment of the leaf are densely hairy. Two prominent awl-shaped stipules about two inches long occur at the base of each leaf. They are united at the base with the petiole and with the petiole clasp the stem like the leaf base of a palm.

The pale yellowish-white or greenish-white flowers are borne in many-flowered umbels five inches in diameter that are arranged in large, terminal, drooping plume-like, densely tomentose panicles. A large plant may have a dozen or more plume-like panicles that are one to three feet long (22). The flowers are tetramerous or pentamerous, with two styles. The calyx is densely tomentose. The petals are about one-half-inch long, tomentose on the outside, and separate or united to form an early deciduous calyptra. The fruit is baccate and drupaceous (28).

The plant grows rapidly increasing in height by as much as two to three feet each year until it reaches full stature in its fourth or fifth year. Abundant suckers develop at the base of the trunk. They appear in warm climates during all seasons but in greatest numbers after flowering (5).

Distribution. *Tetrapanax papyriferum* is apparently native to northern Formosa and to the South China provinces of Hunan, Szechwan, Yunnan, Kweichow, Kwangsi, and Kwangtung. It may have been introduced to Formosa from the mainland (28). The plant is not known from northern Indo-China or northern Burma.

The rice-paper plant has been introduced into most tropical and subtropical areas, where it is widely planted as an ornamental. It occurs as an escape in Florida. In more rigorous climates it is grown as a greenhouse plant (37).

The plant has been cultivated for many years in Formosa and China. Bowring (7) reported that a large plantation, some "400 le" in circumference, nearly all of

which was devoted to this plant, was in existence at Ke-lung-shan in Formosa about 1850. Hosie (24) in 1922 reported that the plant was extensively grown in Kweichow.

Ecology. The rice-paper plant grows naturally in Formosa at elevations of about 2000 to 4000 feet (31). The climate of this environment is warm-temperate to subtropical. Rainfall is abundant but very unevenly distributed through the year. The period of maximum rainfall is during the warmer months when moisture requirements are highest. Precipitation increases and decreases more or less in proportion to increase and decrease in average monthly temperatures.

According to Morita (31), the rice-paper plant can grow on clay or gravelly soil but is more successful on loams containing a large quantity of organic material.

In general, the climate and soils of the area in Formosa to which this plant is well adapted are similar to the environment of the warmer areas of the southeastern United States. While rainfall in Formosa is higher than in the southeastern United States, the irregular topography of the mountains promotes run-off, reducing the effectivenes of the larger amount of precipitation.

Proschowsky (32) comments that the plant loses its leaves when subjected to a light frost but lives and later produces new leaves. The plant is not winter-hardy in Washington, D.C.

Production and Marketing of Pith

Today most of the pith produced in Formosa is collected from plants cultivated by the mountain aborigines on their reservations.[4] Most is produced in Hsinchu Prefecture in the Northwest and Hua-lien Prefecture in the East. In those areas where pith production is an important industry, cooperatives are established in each aborigine township under the supervision of prefectural governments for assembling and marketing the pith.

Cultivation. In Formosa, according to Morita (31), the plant can be propagated by seed but the percent germination is low and propagation by transplanting basal offshoots is more convenient. These offshoots are removed from existing plantations in spring when about one foot tall. They are transplanted to the field in rows, soon recover, and grow rapidly.

Harvest and Preparation. The plants are preferably cut when two to three years old and the main stems are five to six feet long. The harvest can be conducted at any season, but the winter period, after growth ceases, is considered best. The plants are cut down and the leaves and small twigs are removed. According to Bowring (7), the stems are soaked in running water for several days to loosen the pith and simplify its removal. The main stems and larger branches are then reportedly cut in lengths of 12 to 18 inches. A round stick is held against one end of the stem and is driven against the ground or other solid object to force out the pith (36). The four- to five-foot lengths of pith that we observed and which are shown in Fig. 4 do not appear to have been extracted from the stems in such a manner. These long lengths of pith are grooved and crooked and we doubt that they could be slipped free from the stems so easily. The surface of the pith shows damage that might have resulted from a tool used to split away the outer portions of the stem.

The newly harvested pith must be promptly dried to prevent staining and loss of luster. It is exposed to the sun for several days before storage. According to Swinhoe (36), after removal from the stems the pith may be placed in a hollow section of bamboo culm where it

[4]No information is available on the current production of pith in mainland China.

Fig. 4. Bundles of pith of Tetrapanax papryriferum. (U.S.D.A. Photo, Neg. No. 94760).

swells and dries straight. Several small pieces may be placed in a bamboo culm and forced together during drying. The short pieces adhere to one another and form longer segments.

Marketing. Pith of all lengths is tied with vines or strips of rattan into bundles four to five feet long and two to three feet in diameter (Fig. 4). Such a bundle weighs 20 to 25 catties.[5] The pith is placed on sale in the aborigine villages, where it is purchased by proprietors of the rice-paper factories or their agents.

In their village markets the aborigines currently receive NT \$30 to \$50[6] per catty of pith, according to grade. The best-grade pith is considered to be that which is of medium to large diameter with small interior cavities, a thin, smooth, and bright surface, light weight,

[5] 1 catty = 1.33 lb.

[6] NT \$36 = U. S. \$1.

and pure-white interior. The highest quality pith is said to be produced in Wu Fun Aborigine Township in Hsin-chu Prefecture. The demand for this product is so great that buyers must order and pay cash one year in advance of delivery.

Considerable controversy arises between buyers and sellers over moisture content of pith. The aborigine wishes to market his product with a high moisture content and consequent higher weight. The buyer attempts to degrade such a product and consmuate the sale at a lower than normal price.

Utilization of Pith

Bundles of pith purchased in the aborigine villages are brought to the small rice-paper factories which are located mostly in the lowland cities. Eight factories, each employing eight to twelve workers, mostly women, are located in Hsin-chu. This city is one of the more important centers of rice-paper production. Such small factories individually produce as much as 10,000 catties of rice paper per year. The proprietors contract part of the work to home industries, but most of it is done in the factories.

Cutting the Paper. The bulk of the rice paper manufactured today, both that consumed in Formosa and that exported, is used for manufacture of artificial flowers. The standard sheet size is 3 x 3 inches; this paper is cut in long ribbons from pith segments 3⅜ inches long. Paper to be used for water-color paintings is produced in larger sizes but only on special order. Most commonly, this paper is cut from pith segments four and one-half to seven inches long, but occasionally strips as wide as 13 inches have been prepared. Individual sheets may be joined together with glue to make larger sheets (35). The large sheets employed for paintings are known as t'ung-p'ien (38).

The long dry lengths of pith are first cut to short uniform pieces. Thin ribbons are cut from these short pieces with a heavy-duty, short-handled, razor-sharp knife. The blade of the knife is about twelve inches long, three inches wide, and ½ inch thick along the back (Fig. 5).

Fig. 5. A rice-paper cutter's work table. **A.** *Short rods of pith.* **B.** *Knife.* **C.** *Cutting block.* **D.** *Hardwood hone.* **E.** *Weighted ribbons of rice paper. This cutting block is 17 inches long. (U.S.D.A. Photo, Neg. No. 94762).*

Fig. 6. Cutting rice paper. (U.S.D.A. Photo, Neg. No. 94763).

The cutting block may consist of smooth brick, stone, or burnt-clay tile about fifteen inches long, six inches wide, and one inch thick. Two thin brass strips are joined to the cutting block along the long edges of the flat surface. These brass strips and the skill of the workers are the key factors in the production of a high-quality uniform product. The knife edge is honed frequently on a block of hardwood, obtained commonly from a species of *Prunus*.

Thin sheets are cut from the periphery of the short pieces of pith much as veneer is cut from a log (Fig. 6). A piece of pith is held upon the cutting block, between and perpendicular to the brass strips, with the palm and fingers of the left hand. With the knife held in the right hand so that the blade rests upon the brass strips of the cutting block, a slight longitudinal incision is made in the pith. The cutter then rolls the pith to the left in one continuous motion ad-

vancing the knife smoothly to the left so that its position relative to the periphery of the pith is not changed. A ribbon equal in thickness to that of the brass strips is thus removed. After the pith is rolled across the block, a distance of less than twelve inches, it is returned to the opposite end of the block with the edge of the blade in the same position relative to its periphery. The pith is again rolled over the block. This process is repeated until it is trimmed down to a small diameter. Pith that is solid, that is, non-septate, can be trimmed down to a diameter of 3/16 inch by a highly skilled worker. Septate pith is trimmed to a diameter of about ½ inch. The continuous tangential paring of the pith produces a scroll-like sheet four to six feet long.

The first 10 to 20 inches of the sheet is grooved, irregularly cut, and jagged along the edges or perforated and commonly includes coarse brown areas (Fig. 7). The sheets cut from the interior of the pith are smooth and white, of uniform thickness, and without any break in continuity.

Much care and dexterity are required to produce thin sheets of uniform thickness. Great skill is required to produce a ribbon without flaws at the points where the cutting operation was interrupted to return the pith and knife to the opposite end of the cutting block. A training period of one year is regarded as neces-

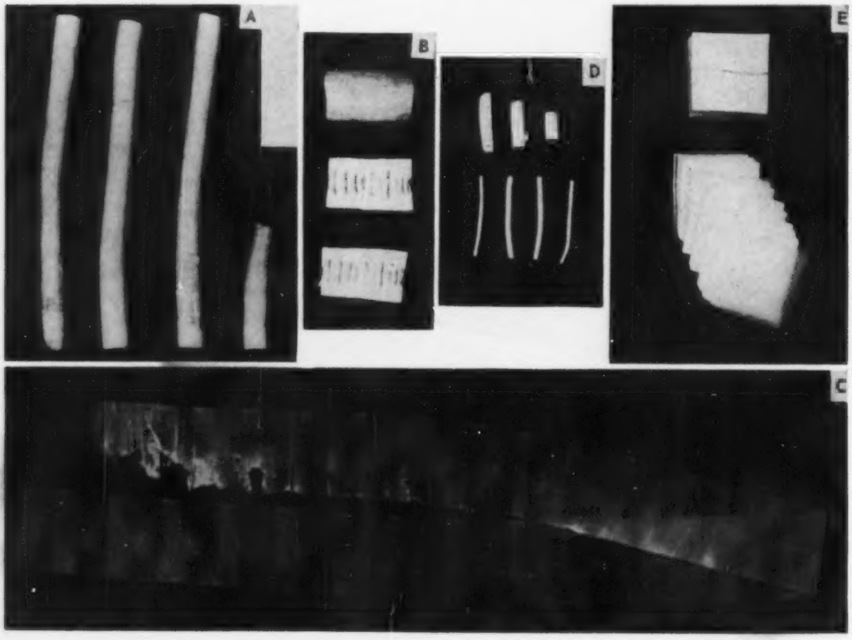

Fig. 7. Stages in the preparation of rice paper. **A.** *Four sections from a long length of pith removed intact from a single plant.* **B.** *Short pieces of pith from which ribbons are cut, the lower split to show the diaphragmed interior.* **C.** *A ribbon of rice paper cut from a single piece of pith.* **D.** *Cigarette-like rods of pith remaining after ribbons are cut.* **E.** *Finished sheets of rice paper. (U.S.D.A. Photo, Neg. No. 94629).*

Fig. 8. A folded bundle of 750 to 1000 rice-paper ribbons (above) and a crate of the finished product ready for shipment to the United States. (U.S.D.A. Photo, Neg. No. 94766).

sary for cutters preparing the narrow strips of rice-paper. Only after many years of experience is a cutter allowed to produce the wider strips used to prepare paper for paintings. According to Hosie (23) the pith cutters in Chungking worked only at night when they were less likely to be disturbed.

The long narrow ribbons of paper are hung over the edge of the cutter's work table with the irregular inferior end of the ribbons cut from the exterior of the pith draping to the floor. A weight holds the ribbons in place. After 750 to 1000 pieces are cut, the stack is removed, folded, and tied with string for temporary storage (Fig. 8).

The bundles are untied later, unfolded, and spread out smoothly in perfect alignment on a table. They are held in place with a brick or heavy metal weight. A string tie is placed 1½ inches from the even end of the bundle and, with a razor sharp knife, the terminal 3¼- to 3½-inch portion of the bundle is removed. Another tie is similarly placed and a sec-

ond cut is made. This procedure is repeated until all but the irregular jagged portions of the ribbons are cut to small square sheets.

The first and second lots of square sheets cut from the large bundle include a few sheets with narrow slits, representing tangential sections through the cavities between the septations of the pith. Sheets of the next eight to ten lots are almost entirely perfect. The remaining lots contain an increasing number of inferior-quality sheets. The sheets removed first and those removed last are carefully inspected to separate all sheets of inferior quality.

The acceptable crude-cut sheets are arranged in groups of about 150 sheets. Each of these lots is placed between two appropriate-size ¼-inch thick blocks of hard wood and the edges are trimmed to the standard size with a sharp knife.

The trimmed paper is tied in packets of about 60 sheets each with slender leaves of a sedge, locally known as "ta chia grass." Five of these packets are tied together with the sedge into a larger bundle. Paper to be exported is packed in light wooden crates constructed of wood of a *Paulownia,* with 400 bundles, each of 300 sheets, per crate.

Grades. The paper is separated into two or three grades, the grade depending more on the part of the pith from which the paper was cut than the proficiency with which it was cut. First-grade sheets are pure white and without any perforations. Sheets that are off color, show brown spots, or include a few small perforations are considered second grade. Those with large, or more perforations or irregular edges are third grade. Most establishments market only first- and second-grade paper, and combine the poorest grade with the waste. The waste is sold in bulk for a small sum. The best-grade paper is exported; the poorer grades are used locally for making artificial flowers.

Wages. For the operation requring the least skill, cutting the long lengths of pith into short sections, the worker is paid about NT $0.35 per catty. For cutting and trimming the sheets the worker receives NT $50 per case of 400 300-sheet bundles. For the operation requiring the greatest skill, cutting the paper ribbons, the craftsman receives NT $12 per catty. The average paper cutter can produce about 2 catties of paper ribbons each day.

Properties of Rice Paper. Top-quality rice paper has a soft-velvety appearance and feel. Newly prepared paper, though fragile, is remarkably resilient and of surprising strength in spite of the lack of fibrous structure, the characteristic which lends strength to traditional types of paper. Its strength is almost uniform in all directions, but a sheet is somewhat stronger diagonally than horizontally or vertically. The paper is somewhat brittle when dry and breaks into small pieces when crushed in the hand. When dampened, the paper can be stretched somewhat without breaking and can be freely folded. When moistened it can be formed into almost any shape and retains this shape during and after drying. Only in an extremely humid atmosphere does the paper become limp and it becomes crisp again when the air becomes dry. The paper becomes increasingly brittle and fragile with age.

Prices. For rice paper packed in crate lots the current price received by the manufacturer is about NT $7.25 per bundle of 300 sheets, equivalent to U. S. $0.20. This price is for first-quality paper, all of which is exported, mostly to the United States. Second-grade paper is sold locally at a price of approximately NT $1 per 300-sheet bundle.

Uses: Rice-Paper Paintings. The art of painting upon rice paper appears to have originated in China early in the 19th century. Early western travelers to the Orient provided a ready market for accurate inexpensive pictorial records of eastern life and the art of rice-paper

painting developed to fill this need. These artistic pieces traditionally portray Chinese products and Chinese life in a most life-like manner. Painters who employed rice paper were, however, considered craftsmen rather than artists because of the realistic manner in which they portrayed their subjects and the lack of imagination that entered into their art. Largly because of the wide use of the photographic camera the art of rice-paper painting has been gradually dying out (12).

Prior to use the paper was commonly flattened under pressure. As the compressed paper was touched with a wet brush the painted surface rapidly expanded and raised up in relief, providing the appearance of fine embossed velvet (2). Brilliant colors were commonly used and these remained fresh and vivid for long periods.

The paintings usually vary in size from 4 x 6 inches to 10 x 15 inches (10). They are very fragile and were commonly bound with ribbon along the edges to prevent injury (5). Prolonged preservation of the paintings requires framing under glass.

The paintings were usually prepared in sets, each portraying a single theme. Chinese professions or trades were favorite subjects for portrayal (10). Extensive use was also made of rice paper to picture birds, insects, fruits, flowers, vegetables, and other objects of natural history (5, 10).

Early collections of rice-paper paintings give no indication of when they were prepared. Albums in the Peabody Museum, Salem, Massachusetts, are dated 1837, 1844, and 1950 with inscriptions apparently made by the original recipient (10).

In present-day Formosa, rice paper is still used as a surface for water colors. A small quantity is used to create simple but attractive paintings for local use. A much larger quantity is now used to prepare very artistic decorative faces for western-style Christmas cards.

Rice paper is especially suited for traditional Chinese-style painting in which much of the surface is left unpainted, in contrast to western-style painting in which paint is applied to the entire surface. The completed paintings are usually matted with narrow strips of silk and covered with a protective sheet of cellophane.

For preparation of Christmas cards an appropriate design is commonly embossed upon the paper by pressing it under an etched zinc plate. After the painting is complete and dry, it is glued to the face of a previously printed card of true paper. The painting is commonly masked, frequently with a paper-thin veneer of camphor wood. These cards retail in Taiwan for NT $15-20.

Uses: Artificial Flowers. Throughout the history of rice paper, a major portion of the product has been used in the manufacture of artificial flowers. It is well adapted for this purpose for it handles well, is easy to work, receives colors readily, and yields a finished product with very natural appearance. The paper is sufficiently strong when moistened and well suited to minute working (2).

The paper furnished to artificial flower makers was usually plain and undyed, and cut into sheets about three inches square. These small sheets were made up into bundles (36).

The methods employed in making artificial flowers varied considerably according to the imagination of the individual establishment or craftsman. In some establishments the product was turned out on an assembly-line basis with different workers dying the sheets, cutting the desired shapes, assembling the various pieces, and applying the final touches.

At the turn of the century two- to three-thousand persons were employed in the making of flowers in Canton and Hong Kong (2). About this time large

quantities of rice paper were shipped to Japan. Japanese workers prepared excellent imitations of favorite American flowers such as roses and violets, much more realistic than their reproductions of such typical Japanese flowers as chrysanthemums and cherries (1). The finest artificial flowers realized a price in the United States of as much as $1 each (1). Artificial-flower makers in the United States were soon using rice paper in preference to such traditional materials as muslin, silk, satin, and velvet (1). Artificial-flower making for local consumption is a small industry in Taiwan today. A state-supported school has been established for training young women in this craft. A wide variety of artificial flowers, some extremely accurate reproductions, are currently made. The paper is cut to appropriate shape, dampened between moist towels, and formed with variously shaped, convexly surfaced, smooth metal tools.

A major portion of the rice paper prepared in Formosa is exported to the United States. The paper imported into this country is used, as far as we know, only for the preparation of artificial flowers. With very few exceptions, commercial flower makers no longer use rice paper; all or most of the product now marketed in the United States is destined for retail sale in small quantities through craft or hobby shops. A brief illustrated article on the preparation of artificial flowers from rice paper appeared in a 1949 issue of a popular magazine (9).

Rice paper is available as "wood fiber" in American retail outlets in more than 70 different colors in sizes ranging from 3 x 3 inches to 6 x 6 inches. A package of 50 to 75 small sheets retails for about $.50. The 6 x 6-inch sheets retail for about $.10 per sheet. Also for sale are precut petals designed for the preparation of several popular flowers.

Other uses: In Formosa the scraps and trimmings are used locally for packing glassware and as a stuffing. The trimmings are used as a medicine for diseases of the chest. The slender-cylindrical cigarette-like waste is used by children in school crafts such as the construction of animals, model buildings, etc. The paper has reportedly been used as lens paper (37) and in the preparation of picture postcards, calendars, fans, and menus (2). In Chinese medicine the cigarette-like pieces remaining after cutting the paper were used as a laxative (36). Scraps were employed to absorb the discharge from wounds (38) and to prepare a decoction used as a diuretic (7).

Acknowledgment

Several photographs used to illustrate this paper were made in the factory of the Kinsenhatsu Rice-Paper Manufacturing Co., Ltd., Hsin-chu City, Formosa. The owner of this factory supplied much of the information concerning the manufacture of rice paper. We also wish to extend our appreciation to the Hsin-chu Forest Office and to Mr. Yang Chi-Wei of the Joint Commission on Rural Reconstruction, Taipei, for their assistance.

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BOOK REVIEWS

Semillas y Plántulas de las Cruciferas Cultivadas en la Argentina. J. La Porte. 141 pp. illus. Departamento Editorial, Universidad de Buenos Aires, Buenos Aires, 1959.

The family Cruciferae contains a large number of economically important species, both useful and obnoxious. Seeds and seedlings of horticultural and ornamental species are sold commercially and their correct identification is therefore very important. In the absence of reliable keys for the determination of seeds and seedlings, a premium is put on controlled growings and known sources of supply. The identification of weedy species by means of their seeds that show up as impurities in other crops, mainly cereals, is also very useful. In *Semillas y Plántulas de las Crucíferas cultivadas en la Argentina,* La Porte presents three dichotomous keys by which the genera of Cruciferae cultivated in Argentina can be determined by use of fruits, seeds, and seedlings. As a basis for making the keys, every economically important crucifer known to grow in Argentina was raised to maturity and correctly identified, and seeds, fruits, and seedlings from this material then utilized for further study. Several sources of seed were used in every case to take account of variability.

In addition to the three keys, the introductory chapters present descriptions of morphological characters of cruciferous seeds, fruits, and seedlings; the principal characters of the family and the economic uses of its species; and data on seed germination, these last taken mostly from the literature.

The bulk of the book is devoted to detailed descriptions of all the crucifers cultivated in Argentina, the characteristics of their seedlings and seeds, their economic uses and some general observations. Each description is accompanied by simple but sufficient drawings of the important characters of the fruits and seeds, and tracings of seedlings.

The book is well printed although rather poorly bound. It is intended for use in Argentina, but because the main economic crucifers are the same in most temperate zones, it can have limited use in other countries as well.

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Plants and X-Rays. L. B. Breslavets. Translated from Russian by Alena Elbl, edited by Arnold H. Sparrow. iii + 122 pp., illus. American Institute of Biological Sciences, Washington 6, D. C., 1960. $5.00, individuals and industrial libraries; $4.00 AIBS members and all other libraries; $0.50 additional, foreign.

The nature and contents of this book can best be described by citing from the comments by the editor, p. iii: "This book by Breslavets was published in Moscow in 1946. It is an interesting and useful summary of the older literature in plant radiobiology and covers much Russian work that has not been reviewed previously in the English language and includes some otherwise unpublished data. The book will no doubt be a controversial one because some of the conclusions reached by the author are not generally accepted outside the USSR. One such view is that X-rays stimulate (increase) plant growth or yield to a degree that could be economically useful. This conclusion receives little or no support from recent work outside the USSR and is even questioned in some recent Russian publications."

A three-page introduction includes brief references to the discovery of X-rays by Roentgen in 1895, to Muller's discovery of their mutagenic effect, and to the nature of X-ray tubes, the detection of X-rays, and the old and presently used radiation units. No discussions of radiobiological mechanisms or

theoretical considerations are included. The four chapters that follow consist of individual abstracts of papers with relatively little integrated discussion of the subjects. This compilation is supposedly a relatively complete one, starting with the very first papers on the subject, which were published almost directly after the discovery of X-rays, and including papers that were published just before this book appeared. A total of 474 literature citations is included.

Many early papers of historical as well as scientific interest that may have escaped many of us are now brought to our attention. Schrober in Germany, for example, showed in 1896 that X-rays have no phototropic effect and thus differ from visible light.

While many papers abstracted in this book claim stimulation and growth increases from X-rays, it should be pointed out that others state that such effects were not obtained. One early experimenter (Ancel 1926 in France) pointed out that certain apparent growth stimulations by X-rays may be normal responses to injury, similar to the stimulation of lateral-bud growth in response to injury of the main bud, and that the same responses might be brought about by mechanical injury or by simply excising the bud.

The author of this book is convinced that X-rays do stimulate and increase growth and yields of plant material, and most of her own work would bear this out. She emphasizes that only certain species may be stimulated to growth increases and that some species are so radiosensitive that the weakest doses of radiation (I would presume this refers to the weakest dose within the dose range that will produce perceptible effect) cause only a retardation of growth. She also believes that stimulation or depression of growth is closely correlated with the particular kind of intracellular changes that are produced by the radiation.

There is no question that this book will be found useful to those interested in the literature that it covers and that such readers will be indebted to all those who were involved in making this English volume available. In addition to this more obvious aspect of its usefulness, this book may possibly be a stimulus for botanists to reconsider the possible stimulating effects of ionizing radiations. There have been enough experimental data showing stimulation so that now it is important and necessary to reassess this entire area by a definitive and comprehensive survey of radiation effects in the low dose range.

In regard to the craftsmanship of the book, it might be noted that since the figures (particularly the photographs) are photocopies of a sort, their reproduction is unavoidably poor. The chances of error occurring in the preparation of a book of this type must be great. Only two easily detectible errors were noted: on page 20 it is stated that of plants receiving 250 r, only 63.7 out of 446.5 seeds from these plants, or 35.5% were diseased (this should be 14.3%); and on page 103, unsprouted seeds are said to be more radio-sensitive than germinated ones, which, of course, is not the case. The editor eliminated most errors and contributed further to the usefulness of this book by supplying certain additional literature citations that were absent in the original Russian version.

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Yam Cultivation in the Trust Territory. Frank Mahony *et al.* Trust Territory of the Pacific Islands, Anthropological Working Papers, No. 4, 65 pp. (mimeographed), 1959. $1.00.

A special series on cultivated plants has been initiated as part of the Working Papers issued by the office of the Staff Anthropologist of the Trust Territory. These papers on yams (*Dioscorea* spp.) are followed by others on taro and breadfruit.

This publication is intended to describe ethnographic rather than botanical aspects of yam growing in Micronesia; a hope is expressed in the foreword that the series will be of use in agricultural extension work and in the Trust Territory schools.

The three papers comprising the volume vary in quality and type of approach. (Incidentally, their actual titles differ somewhat from those given on the cover and title page and in the table of contents.) "Ponapean Yam Cultivation," by Frank

Mahony and Pensile Lawrence (pp. 2-13), is the shortest of the papers. It includes details regarding yam cultivation and relates cultivation practices to the prestige aspects of yam-growing among Ponapeans. Yams of great size or age are especially valued, and they enhance the prestige of the grower during ceremonial feasts. Although the paper lists eighty types of yams, and additional sub-types, many of the names given are not translated. Furthermore, no attempt is made to relate native names to particular species of *Dioscorea*.

In the Palau District, despite past efforts by administrators to encourage the use of yams, this crop has low prestige as compared with other starchy foods. Possible reasons for this are discussed in the second paper, "Yam Cultivation in the Palau District," by Robert K. McKnight and Adalbert Obak (pp. 16-37). The paper contains little on methods of cultivation or use, and one gains the impression that the authors relied much more heavily on the statements of informants (whom they sometimes call "sources") than upon field observations. The glossary of native plant-terms (mainly yam names) is like the rest of the article in reflecting an interest in the historical origins of terminology and plant types. The discussions of plant origins are speculative, as they would need to be because historical documents were not available or were not used, because the tentative botanical identifications of native taxa are incomplete, and because the Palauan data were not compared with those from other areas.

"Yam Cultivation Practices and Beliefs in Yap," by Francis Defngin (pp. 40-65), is the longest and most satisfactory of the three papers. It includes data on the cultivation, harvesting, storage, and consumption of yams of various types. In addition, these types are sometimes discussed in relation to their appearance, size and taste. Ceremonial uses, prestige evaluations, magic, miscellaneous beliefs, and a short myth are included. Because almost all of these kinds of data are presented within a framework of three basic types—and numerous sub-types—of yams, the reader gains a coherent picture of the complex of yam-growing activities from the Yapese point of view. As in the second paper, beliefs about the origins of yam types are included, but the native nomenclature is more adequately handled. The three basic native types are identified as equivalent to *Dioscorea alata*, *D. esculenta*, and *D. nummularia* (no authorities given).

It is unfortunate that botanists were not more consistently available to aid these anthropologists in the identification of the plants under discussion. It is also unfortunate that only the third paper makes a real attempt to present native conceptual *systems* (in contrast to simple lists of names).

Any reader is likely to have mixed feelings about these papers. Their inadequacies are obvious, but one somehow appreciates the courage of authors who would choose to publish such uneven and incomplete materials. Surely there is a place in many areas of research for mimeographed working papers. In this case, the publication does contain quite a bit of interesting (though uncoordinated) information about yam-growing in the Trust Territories, and that is all it purports to do.

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Weeds. J. N. Whittet. 404 pp. illus. New South Wales Department of Agriculture, Sydney, 1958. £2-2-0.

This volume, directed especially to "primary producers" in the state of New South Wales, was prepared "to fill a long standing need for a comprehensive work on weed identification and control." The author is an agronomist who for thirty years was in charge of pasture and weed investigations in the New South Wales Department of Agriculture.

Weeds is noteworthy because of the amount of space—the first half of the book—devoted to a discussion of weeds and their control and because of the excellence of this discussion. Topics covered include definition of weeds (defined here to include poisonous plants), methods of reproduction and dissemination, longevity of weed seeds, weeds of special habitats, ways in which weeds are harmful, and the various methods

of weed control. The section on biological control points out the great success that has been achieved in Australia in control of introduced prickly pears (*Opuntia* spp.) by larvae of the cactoblastis moth, which was brought in from Argentina for this purpose. Chapter 5, "Herbicides," deserves special commendation for its clarity and completeness.

The second half of the book contains discussions of 270 species of weeds that are arranged alphabetically by family and genus. Many New South Wales weeds are introductions from abroad, as is true in all countries. Of the eighteen weeds declared noxious throughout the state, only one, galvanised burr (*Bassia birchii*), is a native Australian plant.

As an aid in identification of the various weeds, the book is illustrated with 154 black-and-white figures, 10 black-and-white plates carrying photographs of seeds of 189 weed species, and 52 colored plates. Of the colored plates, about one-third are reproductions of color photographs and are, in large part, regrettably poor; the rest are serviceable drawings. The book closes with an index to common and scientific names, one to colored plates, and one to illustrations of weed seeds.

Weeds is the most comprehensive work on Australian weeds and can be recommended to anyone anywhere who is interested in plants that grow out of place. It will make a worthwhile addition to any agricultural or botanical library. While written primarily for a New South Wales audience, *Weeds* contains much that is of universal interest and use.

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Forage Management in the Northcentral Area. D. Smith. 154 pp. illus. Wm. C. Brown Book Company, Dubuque, Iowa. 1960. $3.25.

This is a well organized and carefully documented compilation of material relating to the culture and use of the major perennial forages sown for hay and pasture in northcentral United States. The author explains plant reactions in terms of physiological and ecological causes and effects, and this explanation helps the student understand the basic principles involved in such reactions. The reactions are related to culture and management in such a way as to tie them into a unified whole.

The first chapter is a brief introductory statement about the area, its historical development of forage crops, and about the major grasses and legumes now used there. Chapters 2 and 3 discuss seeding, establishment, and survival of those crops, chiefly from an ecological standpoint, while the next three chapters emphasize physiological aspects. Chapters 7 through 12 cover the principal legumes, major emphasis being given to alfalfa, the most widely used one. The chapters on legumes are followed by three on management that cover green manures, seed production, and growth response. The next four chapters treat Kentucky bluegrass, smooth brome, timothy, orchardgrass, and reed canarygrass in detail. The last two chapters deal with pasture renovation and grazing management.

Each of the abundant and well chosen references emphasizes some point clearly and concisely. References are listed at the end of each chapter and are chosen to give historical and developmental background as well as recent interpretation. Readers and researchers seeking further and more detailed information along the lines covered in this book should have no trouble "entering" the field of literature at nearly any point.

The author states that the book grew from mimeographed sheets first used in the 1930s in the forage management course taught at the University of Wisconsin. It has been extended to keep pace with the rapid development in this and related fields. Thus, the subject matter covered and the materials used represent the areas needed by students. The book is organized in such a way that each topic leads logically to the next.

The typographical and grammatical errors that appear might easily have been eliminated by closer attention to editing. The writing in the first three chapters tends to be wordy and somewhat awkward in places. In the chapters that follow, the wording is freer, easier, and more concise. Chapter 6 contains an especially clear and easily read description of plant nutrition and growth in terms that apply to forages and forage

management, from both the historic and modern aspects.

There is a strong tendency to interpret plant responses only in relation to conditions that exist in the cooler and more humid portions of the area and to omit mention of the differences found farther south and west. For example, the seeding of perennials along with companion crops is discussed almost entirely from the northern standpoint, although companion crops are seldom used in the drier part of the area. Seeding and establishment also are discussed from the same standpoint. The problems encountered in the drier parts should be covered also.

Natural or range pastures are omitted entirely, although these make up the bulk of the grazing land in the Dakotas, Nebraska, and Kansas. Temporary forage crops such as the small grains, lespedeza, certain sorghums, etc., also are left out.

Despite the few drawbacks mentioned, *Forage Management in the Northcentral Area* is a noteworthy volume, one that all students of forage crop culture must see and use and one whose applications are not so geographically limited as the title may suggest.

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Compendium of Plant Diseases. 264 pp., 125 full color illustrations. Rohm & Haas Co., Philadelphia, 1959. $3.00.

This publication is unique in that for the first time full color illustrations of bacterial, fungus, nematode, and virus diseases of plants are gathered together under one cover. Emphasis is placed on recognition of a disease by its symptoms. The illustrations attempt to cover important diseases of field crops, fruits and nuts, vegetables, and such speciality crops as cacao, coffee, rubber, tea, and tobacco. Although noted by the compilers as being regretted, the omission of diseases of ornamental plants, trees, and forage crops, and of physiogenic diseases caused by higher plants still detracts somewhat from this book. One wonders why a few selected illustrations of such diseases could not have been given. The description of each disease includes symptoms, geographical distribution, economic importance, and general control measures. No specific control agents are mentioned. The compilers state in the preface that "we shall consider this book successful if it emphasizes the importance of plant diseases . . . encourages further study . . . or supplements present information . . ." In this respect the compendium is highly successful and should be well received by all who are interested in plant diseases. It is a job well done.

Certain omissions seem worthy of comment. The colored illustrations were obtained from many plant pathologists. To illustrate the Rhizoctonia disease of potatoes, pictures must have been available of the sclerotia on potato tubers, yet the only illustration used is a picture of the killing of young sprouts. This kiling is a good symptom of the disease and is useful in diagnosis, but is seen less frequently than the sclerotia on the skin of the tuber. I have also seen much better illustrations af apple black rot than the one selected. Similar comments could be made about some of the illustrations of other diseases, but these minor flaws do not detract from the general excellence of this publication. The book should stimulate interest in many fields concerned with plant diseases and be quite useful to many professional pathologists. A copy in every high school library could well be that spark that sometimes is needed to launch a career in plant pathology.

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The Mango: Botany, Cultivation, and Utilization. L. B. Singh. 438 pp. illus. Leonard Hill [Books] Limited, London. 1960. $13.25.

This is the one of a series of publications, *World Crops Books*, on the botany, cultivation, and utilization of various crops. It contains a fairly complete review of literature on the mango with chapters on the following subjects: history, origin, nomenclature, and distribution; botany and rootstocks; cytogenetics and breeding; fruit bud differentiation and periodicity in cropping; climate; soil; varieties; propagation; planting and care; irrigation; nutrition; diseases and their control; insects, mites and other pests; angiospermous parasites and epiphytes; marketing; and utilization.

The book is well illustrated and gives com-

plete instructions on propagation, planting, and orchard maintenance, with particular emphasis on Indian conditions. The chapter on cytogenetics and breeding is particularly useful because this phase of research on the mango has been badly neglected in the past. The chapter on propagation is somewhat confusing. Many methods of propagation that have been tried in various countries are reviewed, and the extent of usage of these methods is included in the review. Because some of the literature cited in these reviews is 30 or 40 years old, the reader has little idea what methods are currently favored in various mango growing regions. The chapter on varieties explains the different systems of describing and classifying mangos, but many questions about the Indian varieties remain unanswered. For example, what is meant by "degeneration" of a variety such as is described for the Bombay Green? What is meant by different "types" of the Baramasi and Mulgoa varieties? Are these "types" variants obtained from seed, or bud sports, or are they unrelated varieties of similar appearance or prehaps common geographic origin? The chapter on varieties concludes with a list of 23 Indian varieties that are considered topmost for taste and flavor. This list will be welcomed in all mango growing areas where attempts are being made to obtain the best varieties. It would be interesting to know to what extent these varieties are grown in India.

The chapter on marketing is rather short. Statistics on production and marketing, which would show where the markets are located and give some idea of the yearly consumption of mangos, are not included. The chapter on utilization is lacking in information on canning of ripe mangos. The reader may wonder how important canning is and whether any commercial canneries exist.

Judging by the dates of references, there appears to be a lag of about four years between time of compilation of this material and publication. Nevertheless, this book should be well received by all who work with mangos. It should find a place in every good library on tropical fruits.

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Guide to British Hardwoods. W. B. R. Laidlaw. 240 pp. illus. Leonard Hill [Books] Limited, London, 1960. 30s.

This book is intended primarily as an identification manual for the native and commonly cultivated broad-leaved trees of Britain. Secondarily a select group of the most popular cultivated shrubs and woody vines is also treated.

One chapter is devoted to those aspects of elementary botany that are helpful in plant identification. Especially excellent are two tables, one itemizing field characteristics of the trees and the other giving a seasonal history of each of the common British hardwoods. The first table briefly itemizes the characteristics of each tree's bark, branches, branch habit, foliage, flowers, fruit, autumn color, etc., in such a concise manner that these features can readily be compared among related species to aid in quick field determination. The seasonal history chart divides each month into three parts and then indicates the approximate time for leafing, flowering, fruiting, and defoliation of the common trees.

The main portion of the volume is devoted to concise descriptions of the species. All matter which would appear to be superfluous to ready and accurate identification of hardwood trees has been omitted. Floral formulas are employed. The line drawings are well done and quite detailed. For example, the illustration of the common beech shows the twig, leaf, flowering twig with male flowers and female flowers, fruiting twig, cupule with one nut removed, open cupule, and an illustration of a single nut. The fine treatment of *Populus* gives listings of synonymy, and illustrations of half a dozen hybrids in addition to the species. A glossary and a short bibliography are included in the book.

While the key to winter twigs is excellent, there would appear to be some shortcomings in the key to trees in summertime. Here the statements are made that box elder has palmate leaves, that sweet gum is a smooth-barked tree, that tree-of-heaven and black locust always have at least 10 pairs of leaflets, that *Laburnum* has a non-flattened pod, and that elder, dogwood, and *Viburnum* have their flowers in umbels. However, these errata are obviously minor

in relation to the over-all usefulness of *Guide to British Hardwoods.* I wholeheartedly recommend the book for the identification of hardwood trees in the geographical area for which it is intended.

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Diseases of Farm Crops. A. Beaumont. 128 pp. illus. W. H. & P. Collingridge Limited, London, 1959. 25s.

This small, unsophisticated book is a primer of plant pathology. It is written explicitly for the benefit of farmers and gardeners who wish to learn something about the nature and control of the more common diseases on crop plants in the British Isles. There is no counterpart in the American literature on plant pathology to which it can be compared. Its purpose is somewhat similar to that of an extension service circular or a farmer's bulletin but it gives fewer details on any one disease and does not dwell on the various deviations and reasons behind the recommendations.

The author has done about as creditable a job as anyone could in 128 pages on the direct task he set for himself. He has drawn upon 35 years of practical experience with plant diseases in central and northern England during his service at the Seale Hayne Agricultural College and as Provincial Plant Pathologist for Yorkshire and Lancashire in the National Agricultural Advisory Science. He readily differentiates between the diseases of economic importance and the less consequential maladies and is prone to recommend well known and fully established control measures with a minimum of attention to experimental materials.

After briefly discussing in the first two paragraphs the types and causes of plant diseases and methods of disease control, the author proceeds to catalog the principal diseases of cereals, potatoes, root and fodder crops, field legumes, pasture and forage crops, grasses, and vegetables grown for human consumption. The principal fungal, bacterial and viral diseases on the major crops in each category are briefly described, and the approved control measures are given. No reference is made to the nematodes either in connection with root rots or as separate problems. The parasitic higher plants and epiphytes are considered only briefly in the opening chapter and are not given a place among the specific diseases on crops. The diseases of fruits, flax, and general horticultural plants are not discussed.

A bare minimum of technical details is given. In the opening chapter, diseases are classified according to symptoms. The life histories of the causal agents are ignored except for mention of the principal methods of dispersal. Scientific names are given so it is possible to identify the diseases even though the local name may be foreign to the average American reader.

Unfortunately, the author has omitted reference to many of the new chemicals in the arsenal of plant pathology. Among the protective spray materials he generally prefers copper or sulfur materials. He does mention the use of Dithane on potatoes in North America. A very useful discussion of dilute and concentrate sprays is included. He reviews the history of seed treatments but gives most of his attention to the hot water treatments for loose smuts, to organic mercurial seed-disinfectants, and to thiram as a seed protectant. No mention is made of captan, and the quinones are dismissed with a single sentence.

The book is technically sound but is often so brief that it leaves the reader with a sense of incompleteness. It is printed on good quality paper stock and is well edited. The black and white illustrations of diseased plants are carefully chosen, neatly reproduced and most effective.

The professional plant pathologist will find very little of interest in *Diseases of Farm Crops.* However the layman who has a plant disease problem and wants to know what the disease is and what can be done about it will find the book useful.

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Nederlandse Dendrologie. B. K. Boom. 4th ed., revised and enlarged. 480 pp. illus. H. Veenman & Zonen N.V., Wageningen, 1959. Hfl. 26,75.

This is the first volume of a projected four-volume reference work on the culti-

vated plants of the Netherlands. The series is under the editorship of the same Dr. Boom, who is a taxonomist on the staff of the Institute of Horticultural Plant Breeding at Wageningen. This first volume describes the hardy woody plants (trees, shrubs, and woody vines) cultivated in Holland. The second volume takes up the outdoor herbaceous plants, and the third and fourth volumes, in preparation, are concerned with succulents and hothouse plants, respectively.

The *Dendrologie* is, in its organization and content, very closely comparable to Rehder's *Manual of Cultivated Trees and Shrubs*, a standard reference work among commercial and professional plantsmen in the north temperate zone. Dr. Boom's book, though written for a public limited by language, and covering a very small portion of the earth's surface, has nevertheless proven to be fully justified. The importance of horticulture, and especially of the nursery business, in Holland is well known, and this book, while scholarly and academic in form, is of great practical utility to commercial nurserymen, both in determining their plant materials and in bringing their nomenclature into line with standard usage.

The fourth edition differs from the third chiefly in two respects: first, in the rigorous and consistent application of the International Code of Nomenclature for Cultivated Plants as published in *Regnum Vegetabile*, Volume 10, 1958; and second, in the greatly increased listings of cultivars. For example, the third edition has nine entries for taxa below specific rank under *Acer platanoides* L., all Latin in form, in the typography of botanical taxa. The fourth edition has fifteen entries, every one of which is treated as a cultivar, several names being in modern language. It should be pointed out that in certain genera, such as *Rosa*, Dr. Boom makes no effort even to list all the cultivars grown in Holland, since their number is legion and their popularity is transitory.

In this change of treatment between the third and fourth editions, Boom also departs radically from the traditional concepts of nomenclature followed by Rehder in his *Manual* (second edition, 1940) and in his *Bibliography of Cultivated Trees and Shrubs* (1949). Rehder considered his own work to be primarily botanical, and therefore he did not feel obliged to list such selections as originated under cultivation *if they were clones*. He treated as botanical taxa (usually in the category of forma) all such variants as had been described as occuring in nature, or as appearing more than once in cultivation. The International Code, however, does not limit the concept of cultivar to clones, and therefore Boom and other taxonomists of cultivated plants, especially in Europe, are making wholesale changes in the status of variants from forma to cultivar. In many cases the changes do not seem justified and create even worse problems.

The introductory pages of the *Dendrologie* include a clarification of the rules of nomenclature, an illustrated glossary of Dutch descriptive terms, keys to the genera (one key based on leaves; the other, illustrated, on twigs), and a key to the families on the basis of flowers. The body of the book consists of a review of all the plants covered, organized taxonomically according to the Engler and Prantl system. Within the larger genera there are keys to the species. For each taxon a description is given, usually so worded as to emphasize distinguishing contrasts. For each there is also brief synonymy, and brief notes on region of origin, introduction into cultivation, frequency in Holland, and hardiness. All keys in the book are dichotomous, and all seem clear and usable. There is further help for determination in the form of 133 figures (many of them full-page) of leaves and other diagnostically helpful features. The volume concludes with a biographic list of authors of the plant names and 31 pages of index.

Users of the book outside of Holland are confronted with the twin limitations of language and geographical scope, but both of these limitations are more apparent than real. As for language, the universality of nomenclature makes any such manual usable to some degree by anyone who knows the Roman alphabet; furthermore, Dutch is so typically Germanic that it is easily learned—for reading purposes—by any native speaker of English, German, or a Scandinavian language. As for geography, Holland's cli-

mate is so mild and the interest of the Dutch in plants so intense and long-standing that the *Dendrologie* covers an enormous range and quantity of plant material. In a dynamically changing field, with Rehder's *Manual* now over 20 years old and no comparable later work in English, the English-speaking plantsman must cross these small barriers if he is to be well informed.

The basic organization of *Dendrologie*, systematic as opposed to alphabetical, has its drawbacks. Systematic sequences, of course, attempt to follow one or another theory of plant evolution and relationship, as deduced from morphology. Now, this manual is used mainly for keying out specimens of unknown identity and for seeking information on known taxa. In the former case the systematic arrangement may be helpful, but in the latter case it is pointless; one must constantly use the index, and for many users the extra time required is a major item. This objection is especially valid in a book that treats such a large percentage of cultivars; these are of interest largely to commercial plantsmen, who are not concerned with system.

For those plantsmen who wish to become familiar with the application of the International Code of Nomenclature for Cultivated Plants, Dr. Boom's *Nederlandse Dendrologie* is excellent training. The Code is often compromising and ambiguous, but Boom's applications are so firm and consistent that his work may well be taken as the standard, in preference to the rules themselves. While specialists may quibble with his treatment of certain taxa, few will deny that Dr. Boom has here continued and advanced his fine tradition of both scholarly and practical handling of the difficult field of cultivated plant taxonomy.

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Commercial Foreign Woods on the American Market. David A. Kribs. 203 pp. 480 figs. Published by the author. Pennsylvania State University. University Park. 1959. $30.00.

Although not so designated in this volume, Professor Kribs' latest book appears to be an enlarged and somewhat emended version of his work by the same title published in 1950. The format is about the same as that of the 1950 book and consists essentially of descriptions of timbers arranged alphabetically by species within the appropriate family. Each description comprises the binomial, a selected commercial name, a list of other names, an outline of general properties, a more or less extended listing of microscopic anatomical characters, and a final selection on uses and sources of supply.

The aims of the volume are ". . . to provide a general reference to commercial foreign woods on the American market and to clear up, if possible, the existing confusion concerning trade names for timbers imported into the United States." Professor Kribs has chosen, for the commercial names listed, those that seem to have been widely adopted in general use. In contrast to the 1950 edition, which contained dichotomous keys for identification of the timbers considered, the 1959 edition contains no such devices, but the author explains how a key-card sorting system may be prepared from the information given in the descriptions. An illustrated glossary of descriptive terms precedes the section on wood descriptions. The appendix contains photomicrographs of transverse and tangential sections of the over 400 woods. A list follows in which species, arranged by commercial name, are categorized as to usage. The general bibliography is identical with that in the first edition; however, two further lists of literature are appended, one containing references to works on physical and mechanical properties, and the other to a few works on vernacular and trade names. An index to common names, genera, and families completes the volume.

Since Professor Kribs' 1950 and 1959 publications are the only volumes of their kind to appear in the United States, one must applaud the issuance of the second enlarged edition. However, the enthusiasm with which one normally greets a new treatment is somewhat mitigated when one examines this latest effort, since in effect it is an enlarged, but otherwise little improved version of the 1950 work. I was disappointed to see the omission of the dichotomous key to species. True, dichotomous keys to woods leave much to be desired, but at

least there was some device for identification in the 1950 book. In this 1959 edition, the reader must prepare several hundred data cards, a most time-consuming process, if he wishes a means for the identification of the woods. It was also discouraging to find the identical illustrated glossary and the unaltered list of general references. Several new works have appeared since 1950 which replace those in the original list of references.

Questions will also arise in the minds of readers concerning the audience for whom this book is intended and for what purposes it is to serve. The author is vague on these points. One would expect a volume on commercial timbers to be prepared for lumber importers and converters and users of exotic woods. Students in forestry schools would also benefit from such a treatment. However, *Commercial Foreign Woods* will be most valuable to those possessing a good working knowledge of microscopic wood anatomy. Lumber importers and others not versed in the parlance of anatomy will find a large part of the text beyond their understanding. On the other hand, students in wood anatomy and identification will see in this volume a reference and guide to the structure of commercial exotic timbers. In those institutions where wood identification is a vocation, Professor Kribs' book will prove a highly useful tool. As Professor Kribs suggests, whether it will be possible to bring order to the chaos of commercial names, by his selection of names which have been widely adopted in general use, is questionable. In this regard lumber importers and promoters of exotic timbers are their own worst enemies, for they add to the turmoil by coining still more names intended to glamorize their products.

Only 200 copies of Professor Kribs' book were lithoprinted, hence, the excessively high cost. There is little doubt that for most private individuals $30.00 will be prohibitive. The physical appearance and binding are satisfactory and are a distinct improvement over the soft cover, spiral type binding in the 1950 edition. Because it is unique and represents a good compilation of facts, *Commercial Foreign Woods* will find a ready place on the reference shelves of libraries, and in the hands of wood anatomists and technologists.

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Advances in Applied Microbiology. Vol. II. Edited by W. W. Umbreit. 384 pp. illus. Academic Press, Inc., New York, 1960. $12.00.

Following the favorable response to Volume I, the editor has expanded Volume II to cover a larger area of interest to the applied microbiologist. *Advances* is serving admirably in providing a means of communication for groups of diverse interests and backgrounds.

Newer aspects of waste treatment with special reference to dairy wastes are discussed critically by the late Nandor Porges. The general nature and applications of aerosol samplers and of aerosol-characterizing equipment is reviewed by Harold W. Batchelor. F. Kavanagh presents an essay on microbiological assaying in which he stresses, among many other points, the importance of proper dishwashing of the glassware to be employed and the advantages of having one operator perform most of the steps of the assay rather than having an assembly line. The membrane filter technique is now recognized as a standard method for the bacteriological examination of water and sewage. Richard Ehrlich discusses other applications of the filters, including isolations of specific organisms, and medical, clinical, and aerobiological analyses.

Additional roles of microorganisms are discussed in reviews concerning microbial control methods in the brewery, by Gerhard J. Haas; newer developments in vinegar manufacture, by R. J. Allgeier and F. M. Hildebrandt; and microbiological transformation of steroids, by T. H. Stoudt. A pertinent article relating to man's future well-being is ably presented by two engineers, W. J. Oswald and C. G. Golueke, of the University of California at Berkeley. They evaluate a laboratory microbiological process that converts solar energy to electrical power through algal photosynthesis, methane fermentation of algae by bacteria, and finally thermal combustion of methane.

The last section of *Advances* is devoted to

a symposium on engineering advances in fermentation practices. It consists of eight papers presented before the Division of Agricultural and Food Chemistry, 136th meeting of the American Chemical Society, held in Atlantic City in 1959. The titles include: "Rheological Properties of Fermentation Broths," by F. H. Deindoerfer and J. W. West; "Fluid Mixing in Fermentation Processes," by J. Y. Oldshue; "Scale-up of Submerged Fermentations," by W. E. Bartholomew; "Air Sterilization," by A. E. Humphrey; "Sterlization of Media for Biochemical Processes," by L. L. Kempes; "Fermentation Kinetics and Model Processes," by F. H. Deindoerfer; "Continuous Fermentation," by W. D. Maxon; and "Control Applications in Fermentation Processes," by G. J. Fuld.

The caliber of the reviews in this volume is at a high level. The editor of *Advances*, it is hoped, will be able to maintain these standards.

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Biological and Chemical Control of Plant and Animal Pests. Edited by L. P. Reitz. 285 pp. illus. Publ. No. 61 of the American Association for the Advancement of Science. Washington, D. C., 1960. Price \$5.75; \$5.00 prepaid to AAAS members.

The nineteen papers included in this volume were selected from a symposium presented by Section O on Agriculture at the Indianapolis meeting of the AAAS, December 28-30, 1957. They are organized into three sections: (1) The Public's Stake in Pest Control—five papers, (2) Recent Advances in Chemical Control—four papers, and (3) Biological Control of Pests—ten papers. Considered of particular interest to economic botanists are the following ten articles: "Exclusion and eradication versus reduction of plant and animal pests," by M. R. Clarkson; "Control of forest diseases," by J. R. Hansbrough; "Fungicides and bactericides for controlling plant diseases," by George L. McNew; "Chemical weed control," by R. H. Beatty; "Antagonism as a plant disease control principle," by William C. Snyder; "Nutrition of the host and reaction to pests," by J. G. Rodriguez; "Effects of disease and insect control practices on biological balance in apple orchards," by A. D. Pickett; "Breeding field crops for resistance to diseases," by Ernest H. Stanford; "Breeding vegetable and fruit crops for resistance to disease," by J. R. Shay; and "Breeding plants for resistance to insect pests," by Reginald H. Painter.

If documentation indicates breadth of coverage, then the articles by McNew and Rodriguez, and "Chemical control of internal parasites of domestic animals," by F. O. Gossett can be considered as reviews. An area where the interests of economic botanists and entomologists clearly overlap is indicated in the article by Charles A. Fleschner, "Parasites and predators for pest control," in the discussion regarding the introduction of beneficial insects for weed control.

This collection of papers does not provide the comprehensive coverage suggested in the title. However, between the covers of this small volume is much general information on several approaches to pest control problems in agriculture and forestry which makes factual reading for anyone who wishes to strengthen his background in this important aspect of our national economy.

Economic entomologists are becoming increasingly aware that future insect control programs must be based on sound ecological studies, so that factors such as development of resistance to chemicals and to excessive chemical residues in the soil and on plants will be minimized. That similar problems are shared by economic botanists is apparent from the titles of the last six articles listed above.

Although each title suggests discrete treatment of each particular specialized method of controlling pests, it appears that these articles could be viewed in a considerably broader sense, namely, as representing facets of an integrated pest control program. Such a program demands the compatible and combined use of pesticides and biological antagonists within the framework of adequate ecological study that permits maximum utilization of biological control of the pest species. The practical application of this concept is reported in the article by A. D. Pickett who states, ". . . it is important to avoid . . . in commercial practice, the destruction of biological con-

trol agents . . . to ignore them is unscientific and probably, in the long view, uneconomic."

In the opinion of the reviewer, the integration of disciplines, as well as facets within disciplines, will be a continuing trend in the resolution of pest control problems, particularly as they occur in agriculture and forestry, and will require increasing closer coordination of effort among specialists.

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Cultivated Palms. Special issue of *The American Horticultural* Magazine (vol. 40, no. 1). 189 pp. illus. American Horticultural Society, Washington, D. C., 1961. $3.00.

The American Horticultural Society has done it again! In cooperation with the Palm Society, it has devoted a special issue of *The American Horticultural Magazine* to palms. This follows an excellent series of special issues devoted to plant groups of horticultural interest, but the excellence of the palm issue is unlikely to be surpassed.

Under the guidance of the late R. Bruce Ledin as guest editor, a group of palm specialists and addicts has compiled a series of essays covering every aspect of the palm family in horticulture. In a preface, B. Y. Morrison outlines the aims of the issue, namely, "Tell what the plants look like taxonomically and horticulturally, tell how to grow the plants, outline the difficulties that may arise." These aims have been generously fulfilled by the many authors.

"An Introduction to the Palms," the first major heading, features "Botany and Classification of Palms," by W. H. Hodge; "The More Commonly Cultivated Palms," by H. E. Moore, Jr.; and "The Native Palms," by Robert W. Read. In these, the classification and appearance of palms seen in horticulture are clearly outlined. The keys will prove welcome to anyone growing palms from unidentified seed. The group of line drawings and photographs, "Palm Characteristics, Illustrated," will be very valuable in understanding the technical terms that must be used to define precisely the various portions of the palm plants. A palm portrait section presents 86 photographs of cultivated palms, showing them in all their beauty and grace.

"Culture of the Palms" contains articles on handling of palm seeds, by H. F. Loomis; viability of seeds, by Nat J. de Leon; propagation, by Stanley C. Kiem; fertilization, by Douglas Knapp; pruning, by R. Bruce Ledin; insect pests, by D. O. Wolfenbarger; diseases, by Lorne A. McFadden; and cold tolerance, by Dent Smith. These authors have had wide experience in their subjects. They present an admirably complete summary of the cultural requirements of palms, and point up generally encountered difficulties as well as troubles that sometimes afflict individual species. For those gardeners who would like to try to grow palms in marginal areas, the article on cold tolerance will be particularly useful.

The final section, "Uses of Palms," carries articles by Nixon Smiley, H. F. Loomis, David Barry, Jr., Lucita H. Wait, R. B. Ledin, R. D. Dickey, Nolan W. Kiner, and L. W. Bryan. Here, the planting of palms in special locations and in specific regions is discussed. Many suggestions for aesthetic arrangements are given. "Palms as Hedge Plants" emphasizes a usage seldom thought about in connection with this family of plants because so many of the species are planted as specimen plants. The volume closes with a list of living palm collections (which will be of interest to those of us who must travel to see palms as well as those fortunate enough to live in a warmer climate) and an index. Perhaps the most disconcerting note in the issue is the unfortunate choice of a fluorescent green ink for the printing of the final half-tone on the back paper cover.

From the beautiful full-color illustration of the Christmas palm on the front to the final entry in the index, *Cultivated Palms* is a credit to the sponsoring societies and to its editors and authors. There has seldom been produced so complete and authoritative a compendium on a group of cultivated plants. The type-setting and proof-reading are exemplary, and the half-tones are of the highest caliber. Not everyone may agree with the nomenclature used, but it is undoubtedly as accurate as the present state of palm taxonomy allows. This book will be a stand-

ard volume on the horticulture of palms for many years to come.

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Advances in Agronomy. Vol. 12. Edited by A. G. Norman. 464 pp. illus. Academic Press Inc., New York, 1960. $12.50.

Those concerned with the application of science to crop production and soil management look forward to volumes in this series for reliable summaries of recent research in agronomy. Volume 12 follows the traditional patterns of its predecessors and maintains the same high standards.

The eight major sections of the volume will appeal to a diverse group of plant and soil scientists. The chapter on clay by Rich and Thomas of Virginia Polytechnic Institute is a significant summary of recent findings on the physics and chemistry of clay. This summary will be particularly helpful to soil scientists, but all concerned with soil management will find in it principles of aid in interpreting differences in soil properties. The interrelations between clay and roots in plant nutrition are not reviewed.

The chapter on water infiltration into soil strikes a wider interest than clay mineralogy, although the two are related. This review by Paar and Bertrand of Purdue University is devoted principally to the methods of measuring infiltration, the types of information obtained from the measurements, and the reasons for differences obtained. Since accurate estimates of infiltration characteristics of soils are highly important in planning such diverse management practices as soil erosion control, watershed management, irrigation, drainage, and tillage practices, this attempt to bring order to a complex and confused field is welcome and should stimulate further important developments.

A group of reseachers has contributed important sections on "Technological Advances in Grass and Legume Seed Production and Testing." Increased legume seed yields in recent years seem to have resulted largely from improved control of harmful insects, greater attention to protecting and encouraging desirable pollinating insects, and such improved production practices as row planting and weed control. Alfalfa seed production is being increased particularly by protecting and encouraging some of the wild bee species. Fertilizers and management practices have received comparatively more attention in grass seed production than have insect problems.

Fergus and Hollowell of the University of Kentucky have a chapter on red clover that provides one of the most complete accounts of the agronomic and related practices involved in the production of this important crop plant. There are two chapters on soybeans. One by Ohlrogge of Purdue University reviews some of the general literature on mineral nutrition, and another by Howell, of the United States Soybean Laboratory, bears the title "Physiology of the Soybean," but is limited to the metabolic changes associated with the various stages of growth and the factors affecting these changes. This practical approach is helpful in interpreting field events in terms of soybean metabolic processes.

Soils and crop production in the Southwest are reviewed by scientists of the University of Arizona. The Southwest is a large area with limited water resources in comparison with potential developments in agriculture and industry. The soil and climate are adapted to a large number of crops, but increasing water costs are forcing transitions to a few high income crops.

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Identification of Seedlings of Common Weeds. R. J. Chancellor. 72 pp. illus. Ministry of Agriculture, Fisheries and Food, Bull. 179, Her Majesty's Stationery Office, London, 1959. 4s. 6d.

As the inseparable relationship of plants to broad or to specific habitats is appreciated, the need for means of field identification of seedlings becomes apparent. If weed seedlings can be identified, weedicides may be chosen in terms of the seedlings themselves or of the probability that the seedlings will become noxious in a given habitat.

This bulletin provides for the field identification of seedlings of 87 common dicotyledonous weeds in the British Isles. The characters used for seedling determination are those observable in that stage of growth

during which the plant has cotyledons plus one or two true leaves. Seedlings in this stage are especially sensitive to injury by herbicides. All seedlings are figured twice natural size and rootless, and the figures are standardized, precise, and uncluttered. The plant is seen at an angle of about 45 degrees, the leaves being adjusted accordingly. In several instances this Procrustean bed prevents the figuring of growth aspects or habits that could be of help in identifying the specimen. Information on habitat, prevalence, and growth characteristics is provided. Where species are particular in their choice of habitat, the field observations given are particularly helpful. Sixteen of the weed species covered are considered "never important" to "rarely important"; Illinois has a greater number of important weeds. In practically every species common to both regions, cotyledons of British seedlings are at least half again as large as those of seedlings grown out-of-doors in Illinois during the period of spring winds.

The seedlings are divided into 14 artificial groups separated by differences in or combinations of characters. Perhaps it is inevitable that any key will end up with a group of mavericks not easily organized because they do not fall into clean-cut categories. Despite the excellence and reasonableness of the group descriptions and illustrations in this bulletin, the final group, XIV, must accommodate a difficultly coercible one-fifth of the total number of weeds. Perhaps a certain eclecticism in content of categories would simplify the actual field identification. The eight prominently ocreate polygonums could have been segregated out into one group instead of three. Constant in the genus *Polygonum* are the characteristic revolute margins of the leaf that form tightly rolled longitudinal halves in apposition at the midrib in vernation. No more convenient way of separating *Polygonum aviculare* from *Plantago lanceolata* could be found.

Reduction in number of groups is not so important as the finding of a sharp distinction between two species of similar appearance. To illustrate, *Cardaria draba* is difficult to segregate out into Group XIII because of inconsistencies of leaf margin. The peppery-tasting cotyledons are unmistakably those of a crucifer; the same is true of *Erysimum cheiranthoides*. The attitude of the leaves can be helpful in the field: the leaf folded upward in the bud of *Sisymbrium officinale* differentiates this species from *Senecio vulgaris*, the leaves of which are recurved in the bud. *Sonchus* seedlings are keyed out in this bulletin by means of shape and relative sizes of cotyledons and leaves plus number of teeth, although there is little that is absolute and independent of environmental situations here.

Technical words have been avoided in the booklet. There are a glossary, a short bibliography, and an index. Since the bulletin is for use in the field, it would be desirable to have it in the pocket size now again being popularized.

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The Grasses: Earth's Green Wealth. A. C. Moore. 150 pp. illus. The Macmillan Company, New York, 1960. $5.00.

This attractively printed small book for the layman brings together a surprising lot of material about our most important plant family. Mrs. Moore, a journalist and daughter of botanist Victor King Chesnut, has assembled a very readable lot of information gleaned from her father, other botanists, and publications of the United States Department of Agriculture.

The succinct first chapters on the importance of grasses and their structure and life are followed by those dealing with the economic botany of grains, bamboo, sugar, forage crops, and grasses used for erosion control. The chapter on wheat condenses into 14 pages a description of the different wheat groups and the places they were grown, together with the uses and importance of the kinds of wheat grown today. Discussions of barley, corn, rice, oats, rye, sorghum, and bamboo are even more sketchy. The last chapter, "Grasses to the Rescue," preaches the need for control of soil erosion and praises the valuable work of the United States Soil Conservation Service. The sketches lack titles, contribute little to the text, and occasionally, as the one of sorghum, are in the wrong place.

There are a number of minor errors as well as evidence of unfamiliarity with recent

work on grasses. For instance, the author states, following other writers and some botanists who should know better, "We have hundreds of varieties of corn today but not a single important kind that was not known to the Indians. . . ." Edgar Anderson and William Brown have published conclusive evidence that our common corn belt varieties originated less than 150 years ago as a result of accidental and intentional mixing of yellow northeastern flints with white southern dents.

In spite of these faults, the book will make most readers want to know more about grasses. Mrs. Moore suggests a few titles for further reading; four additional ones might be mentioned. Edgar Anderson's *Plants, Man and Life,* is the best popular account of research on some cultivated plants. Anderson's simple summaries of recent studies on the history of wheat, his entertaining discourses on sunflowers, weeds, and many useful plants, and on the activities of botanists will make almost anyone desire to read more books about grasses as well as other plants.

The person who is really interested in grasses will find no greater bargain than Agnes Chase's revision of Hitchcock's *Manual of Grasses of the United States.* For the beginner there is a simple introduction to the study of grasses, *First Book of Grasses,* also by Mrs. Chase. A useful little book by Richard Pohl, *How to Know the Grasses,* includes brief descriptions of the tribes of grasses and keys and sketches to help identify 293 common kinds.

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Pasture and Range Plants. Section 6: Introduced Grasses and Legumes. Anonymous. 25 pp. illus. Phillips Petroleum Company, Bartlesville, Oklahoma, 1960.

Introduced Grasses and Legumes is the sixth and last of a series of booklets, *Pasture and Range Plants,* published at irregular intervals since 1955 by the Phillips Petroleum Company "to further knowledge of our vital grasses, legumes, and forbs." The first (1955; reprinted 1959) and second (1956; reprinted 1959) sections are subtitled *Native Grasses, Legumes and Forbs;* the third (1956, reprinted 1959), *Undesirable Grasses and Forbs;* the fourth (1957), *Poisonous Grassland Plants;* and the fifth (1958) and sixth (1960), *Introduced Grasses and Legumes.* The booklets were prepared with the "counsel, guidance and technical assistance" of specialists in several plant sciences. The series is available without charge from the Phillips Petroleum Company, Bartlesville, Oklahoma.

The plan of *Pasture and Range Plants* is simple. Some 175 species are illustrated by utilitarian watercolor drawings, usually one species to a page. The selection of plants for representation is a good one. Accompanying each of the illustrations is text that includes descriptions and outstanding characteristics, range, habitat, and forage value of the species; dangerous season and symptoms of poisoning, in the case of poisonous plants; and general comments. Unfortunately, the illustration titled "*Solidago rigida*" (Section 3) shows what is probably *S. missouriensis;* the one titled "*Echinochloa crusgalli*" (Section 3) is *E. pungens;* and the one titled "*Prunus virginiana*" (Section 4) is *P. serotina.* The arrangement of species in each section is enigmatic; various members of a genus may appear on widely separated pages. Individual sections do not have indices. A general index to common and scientific names is given in the final section. The use of this index is somewhat complicated by its division into five primary parts: grasses, legumes, forbs, woody plants, and miscellaneous plants.

Pasture and Range Plants is a reasonably well done series that can be helpful to anyone interested in grasslands of the United States. A second, revised edition in "pocket book" format for more convenient use in the field would be welcome.

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Illustrated Genera of Wood Decay Fungi. C. L. Fergus. 132 pp. illus. Burgess Publishing Company, Minneapolis, Minnesota. 1960. $4.00.

A book should be judged in the light of what it purports to be, or to accomplish, and the degree to which these ends are attained. As a scholarly work it should be reasonably

free from mechanical errors and ambiguous statements. If a book is designed for a group of readers being introduced to a subject, good editing is even more important than in a work for readers already conversant with the materials.

Judged in the light of these standards it may be said that Dr. Fergus had a good idea in publishing a primer on wood-decay fungi. It must also be said that the illustrations are good and for the most part excellently reproduced. The format is attractive, so that the general effect of the publication is pleasing. The spiral binding makes it easy to turn from page to page, and the pages always lay flat when the book is opened, a real advantage in a publication designed for class use.

The author states that the work is designed to fill the need of the general forester, and of students studying forest pathology. In respect to these, the book falls far short of its goal.

First, in a book designed to portray *wood*-decaying fungi, we find too large an assortment of extraneous genera and species. From the standpoint of the general forester and especially from the standpoint of wood decay, a genus like *Septobasidium,* which lives on insects, has no reason for being included. *Phleogena,* although it lives on wood, is of no more importance to the forester or forest pathologist than numerous genera of the Discomycetes, all of which have been omitted. Yet the forester will find 100 or more of these to every collection of *Phleogena* encountered. *Phlogiotis* would have been better omitted because the picture of it does not show the characteristic shape of the fruit body; besides, the species is usually found on the duff of the forest floor. Other genera in the book which do not contain fungi that characteristically cause wood decay are: *Tremellodendron, Craterellus* (as illustrated by *C. cornucopioides*), *Exobasidium, Thelephora* (as illustrated by *T. terrestris*), *Clavariadelphus, Clavulina, Lachnocladium* (as illustrated by *"L. semivestitum"*) and *Sistotrema.* So many extraneous genera detract materially from the work as one seeks to use it for its intended purpose. If the wood-inhabiting genera of fungi were well represented in other respects, and if space still had been available for additional genera, perhaps there would have been some justification for the selections in question. But to leave out whole groups of wood-decay fungi such as members of the operculate and inoperculate Discomycetes and to include many extraneous Basidiomycetes that the general forester will never see, is, in my opinion, inexcusable and bad judgment.

One would expect to find the genera in this work classified according to a system which is conservative and scientific, but not archaic. The classification and the nomenclature used by Fergus do not follow any particular pattern. In the Tremellales he apparently based his genera largely on Martin's works, but neglected to bring the nomenclature up to date. Thus we find *Tremellodon* used in place of *Pseudohydnum,* a most admirably descriptive name. In a work of this type the author should have recognized his duty to give his readers and users the best of modern classifications and nomenclature. In this respect he failed completely. He uses an ultramodern classification of the coral fungi, even to the extent of including genera completely extraneous to his avowed aims, and then in a group such as the agarics he fails even to cite Singer's monumental work and gives the classification of the gill fungi used at the turn of the century. The work would have been better if he had omitted the coral fungi, even though a few species are lignicolous, or simply used the old Friesian name and called them all *Clavaria.* Such nomenclatural changes as *Volvariella* for *Volvaria* in the agarics should have been made. The author must have had Shaffer's monograph of the genus (published in *Mycologia*) on his desk when he worked on his manuscript. Sometimes his captions do not check with what is shown in the photograph, as in the case of *Pholiota adiposa.* His illustration shows a fibrillose veil, yet the caption points out that the annulus is membranaceous. No scientific or sentimental reason can be found for including *"Claudopus nidulans"* in *Claudopus,* although a difference of opinion over whether the species should be placed in *Pleurotus* or in *Phyllotopsis* may be considered understandable. The agaric part of the work is full of contradictions based on the author's failure to consider work of the last 30 years. He says of "Flammula" that the basidio-

spores are smooth, and yet the first species keyed out has roughened spores.

The heart of any treatment of wood-decay fungi is the family Polyporaceae. In the work of Fergus this group has been short-changed, reducing the usefulness of the publication as a laboratory reference in forest pathology. The eight and one half page key to the Polyporaceae keys out a large number of species, but the key characters are not, for the most part, critical, and there is no supporting information to aid the student in deciding whether or not he has the right fungus. The success of such a venture as this book centers around the judgment and skill used in treating the woody pore-fungi. In this area Dr. Fergus's work leaves much to be desired.

Perhaps the best that can be said for the work editorially is that fortunately there is very little introductory material to confuse the reader. To most of us there is a world of difference between *decaying fungi* and *fungi causing decay*, but what is really appalling is trying to visualize the situation in which ". . . the decaying fungi attack slash. . . ." On p. 66 we find this statement: ". . . basidiocarp brick red in color; basidispores ellipsoid, hyaline, with setae in the hymenium." Such lack of attention to detail mars the book.

In summary I can say only that idea of a work on fungi causing wood decay is a good one, and it is hoped that the author will immediately revise his book on a scientific basis, which will give an even, accurate, up-to-date treatment for all groups included. Much of the necessary literature, I am sure, is already on the author's desk.

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Plant Disease Handbook. Cynthia Westcott. 2nd ed. 825 pp. illus. D. Van Nostrand Company, Inc., Princeton, New Jersey. 1960. $13.50.

This is a modernized version of the first edition, which was published in 1950 under the same title. The author has revised and supplemented the information on disease control measures with particular attention to new organic chemicals and antibiotics that have been developed during the past decade and shown to be effective. The general format remains the same, with only minor revisions in description of the individual diseases, some reorganization such as combining the anthracnose and scab diseases, and expansion of the nematode section to keep it abreast of rapid current developments.

The book is carefully written in a straightforward, intelligible style. To differentiate between essential and irrelevant facts that can be useful in applying the arts of plant disease control, the author has drawn upon her extensive practical experience as a practicing plant doctor for the past 30 years. She very well defined the position of this book in the preface to the first edition by writing, "The result is neither a comforting bedside volume for the first-year gardener nor a treatise for the specialist in the field." However, she has drawn from the best knowledge of one group to help the other, and perhaps nowhere else in our current literature can one find so much valuable information in such concise and usable form.

Words of practical wisdom and warning are freely offered to help the gardener make sensible use of the information. "This is a reference manual. You will not read it through from cover to cover but . . ." (page xi). "The chief hazard any garden plant has to endure is its owner or gardener. . . . It is human nature to read symptoms of an ailment and immediately assume it is your own affliction. Jumping to conclusions is as dangerous to plants as to animals. . . . A spotted or yellowed rose leaf does not necessarily mean rose blackspot. . . . Yet gardeners blithely go on increasing the spray dosage, confident that more and stronger chemicals will lick the 'disease' and seldom noticing they are nearly killing the patient in the process." (page 1)

Some 2,000 diseases are catalogued according to the cause or inciting agent, with secondary grouping according to type of disease such as anthracnose, leaf blight, wilt, etc., in Chapter 4 (pp. 47 to 452). This semitechnical organization brings many diseases together in workable groups so they can be discussed intelligibly. The practical reader is saved from wallowing in hopeless confusion by a sensible and practical host index in Chapter 5 which lists the principal diseases for each ornamental and horticul-

tural crop grown around the home. This serves as a cross index which the amateur can use in narrowing down the range of possibilities for a given malady and from which he can proceed to the detailed descriptions in the preceding chapter. In turn, the scientific names of the fungi, bacteria, etc., given in the descriptions lead the reader to a discussion of the causal agents, which are classified in Chapter 3. Thus the practical gardener may work his way back from the host to the symptom and to the cause, and he possibly may verify the cause by the signs of fungus or bacterial growth.

The volume is made very usable by a rather complete nine-page glossary of technical terms, eight pages of bibliography citing more extensive and detailed treatises and standard texts and reference books, and an index embracing hosts, causal agents, common names of diseases, and control measures.

The book is well edited, is printed on high-quality paper stock, and has 112 well chosen illustrations of diseases and causal agents. It is a fine treatise that can be recommended without any serious reservation to those who would like to know more about the problems of plant health in the home garden and ornamental plantings. Some professional plant pathologists could profit from imbibing some of its common-sense philosophy and balanced judgment. It will be a handy reference on the book shelves of any plant pathologist.

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Rhododendrons and Azaleas. Clement Gray Bowers. 2nd Ed. 525 pages. illus. The Macmillan Co., New York. 1960. $25.00.

The first edition of this book appeared in 1936. Since it went out of print a few years ago, the demand was such that some copies sold for six times the original price. With the new edition, we again have an up-to-date treatise, which is still the most comprehensive available reference on the origins and kinds of rhododendrons and on their culture in American gardens.

Although the format of the original has been largely retained, the new edition benefits by limited reorganization of subject matter and division into three parts. Part I is concerned with the living plant, its origin, culture, nutrition, hardiness, reproduction, inheritance characteristics, propagation, and pests; Part II contains descriptive notes and compilations on the series, species, and cultivars; and a shorter Part III is made up of miscellaneous adaptability listings and keys.

Comparison with the earlier volume shows that much rewriting has been done, older information has been updated, and new information has been added in many areas with sometimes rather striking effect. The change in emphasis in propagation techniques over a 25 year period is readily detectable, for instance, in the discussion of cuttings, which has been expanded from a single paragraph to several pages, and in the location of this discussion before that of the grafting process rather than after, as in 1936.

Listings of the species are considerably expanded and those of the cultivars improved by the dropping of many obsolescent names, the addition of newer ones of current interest, and the arrangement of rhododendron clones on a simple alphabetical basis. The azalea listings retain the parentage or breeder-group breakdowns and are less changed than the rhododendrons except for addition of such newer groups as the Knaphill hybrids, Glenn Dale hybrids, etc. In neither case are the listings intended to compete for completeness with the *International Rhododendron Register* or with the latest *Rhododendron Hand Book* of the Royal Horticultural Society for detail of parental origin, but their coverage should prove adequate for most normal reference purposes.

Hardiness and merit ratings, where used, remain primarily pegged to the British rather than to the more recently developed American system—a point which may be regretted by those who have become accustomed to the latter and who feel, rightly or wrongly, that the shortcomings of its youth are outweighed by its better adaptation to a differing climatic situation.

A valuable addition to the keys to the series groupings of azaleas and rhododendrons is to be found in a realignment of the series pattern in terms of an abbreviated version of Sleumer's systematic arrangement of the genus, including his recent treatment of the Malaysian groups.

The bibliography, which is good, is, however, the most noticeable victim of incomplete revision. Since new titles have been added to but not incorporated with the old, it is necessary to check in two places for complete coverage under the subject headings. Inflorescence figures of additional rhododendron varieties derive from successful water colors by the author.

Rhododendrons and Azaleas is essentially a horticultural book, but both quality and the broadness of its coverage will insure this book a continuing place among the most significant treatments of this ornamentally important genus.

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The Chemistry and Technology of Fertilizers. Edited by Vincent Sauchelli. 2nd ed. 692 pp. illus. American Chemical Society, Monograph Series, No. 148. Reinhold Publishing Corporation, New York, 1960. $18.00.

In the world-wide fertilizer industry, the last quarter century has been characterized by an almost explosive expansion of production facilities, accompanied by a very rapid evolution in manufacturing technology. This book fills the need for a thorough, up-to-date compilation of important developments in the numerous areas of endeavor within the industry and should serve as an extremely useful reference work for engineers, chemists, management personnel, and others who have an interest in fertilizer manufacture.

The subject is treated in 24 chapters, written in each case by acknowledged experts in the field. The book begins with a chapter devoted to the manufacture of solid and liquid nitrogenous fertilizer materials. This is followed by 12 chapters covering the geology, mining, and processing of phosphate rock and the production of phosphate fertilizers and by one chapter dealing with the occurrence and production of potash materials. Other subjects treated in separate chapters include the production of granular and non-granular mixed fertilizers; the manufacture of liquid fertilizers; technological problems such as corrosion, caking, and the handling of toxic off-gases; minor and secondary elements in mixed fertilizers; materials-handling equipment; and structural and x-ray data on compounds found in fertilizers, with emphasis on the influence of structure on behavior.

The type-font and the printing format are excellent, and the many diagrams, charts, and illustrations are clearly shown. However, one cannot help but note the rather numerous errors of both omission and commission that occur throughout the volume and detract somewhat from the generally high quality of the presentation. Among these may be mentioned the inexplicable placing of Chapters 11, 20, and 21 out of logical sequence, the inclusion of tables (for example, tables 7.3 and 7.6) without mention of them in the text, the reference in tables to non-existent notes (table 7.6), statements directly opposite to those given in the cited references (p. 161, line 1), the omission or minimization of table headings (tables 1.11, 1.12, 7.7), the omission of dimensions in figures (figures 6.1, 12.2, 12.3), and a number of other erroneous statements, headings, equations, and the like.

It is to be hoped that these simple faults will be corrected in future editions of the book and that the subject matter will be rounded out by treatment of such topics as the synthesis of ammonia and the production of elemental phosphorus, furnace-process phosphoric acid, and superphosphoric acid. Despite its shortcomings, the present volume is an important and welcome contribution in its field.

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Horticultural Pests: Detection and Control. G. Fox Wilson, revised by P. Becker. 240 pp. illus. Crosby Lockwood and Son Ltd., London, 1960. 25s.

This book is intended primarily as a guide for horticulturalists, agriculturalists, and gardeners who do not have the necessary training to comprehend technical details concerning the distinctive characters of animals that may attack crops. It is not intended for the entomologist although the book will be useful to those concerned with agricultural entomology.

Pests are discussed according to the symp-

toms that appear on the plants after attack rather than according to the more conventional means of animal classification or host range. For example, the book is divided into sections corresponding to the main parts of plants: bulbs, corms and tubers, roots, stems and shoots, etc. The individual chapters are headed roots galled, roots overdeveloped, stems dying back, stems galled, foliage eaten, etc. Within each chapter, the pests are identified by the particular type of damage done, and control measures are given. When a particular pest causes more than one type of damage, the reader is referred to the section where the pest is discussed in most detail.

A knowledge of symptomatic detection of plant pests is very important to those conerned with general aspects of horticulture, and the book presents a complete discussion of insects and related pests that damage crops. Since the book was written primarily for use in England, most of the pests are European; some do not occur in the United States. However, many occur in both areas, and related pests can be recognized because of similar damage symptoms.

In order to acquaint the reader with the fundamentals of entomology, the opening chapters deal with type of pests, life histories, feeding habits, and effects of pests on plants. A chapter discusses control measures such as chemical, mechanical, biological, and physical. The revised edition is especially complete and up to date with regard to chemical control. Both the most recent compounds and the older, standard materials are included. The book is profusely illustrated with black and white photographs in addition to color plates. This feature aids in identification of symptoms and provides an additional means of checking a diagnosis. *Horticultural Pests* provides a vast fund of information and will be extremely valuable to students of horticulture, commercial and amateur growers, nurserymen, and regulatory officials concerned with plant inspection. Plant pathologists, nematologists, and others will also find it useful as a means of recognizing damage caused by insects and related pests.

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Loblolly Pine: ts Use, Ecology, Regeneration, Protection, Growth and Management. W. G. Wahlenberg. 603 pp. illus. Duke University, Durham, North Carolina. 1960. $7.00.

Loblolly pine (*Pinus taeda* L.) is one of the leading timber species in the South, and some regard it as the second most important timber species in the world. In recent years, foresters have greatly increased their research on the silvics, physiology, and genetics of this tree for the purpose of a better understanding of its culture and management. As stated by W. W. Ashe: "Loblolly pine combines all the essentials for an ideal forest-management tree." It is for these reasons that Wahlenberg wrote this timely monograph, which presents the essence of over 1500 publications and considerable unpublished data. The text, which contains a minimum of technical jargon, is written in a style that is clear and easy to understand. There is much factual information on the structure and life of the species that should be of value as reference material to teachers and researchers in the plant sciences.

It is difficult in a short review to give a fair appraisal of such a comprehensive book because each page is filled with technical knowledge that has accumulated through decades of research. The introduction gives a short but concise review of forest history and the resources of the South. Here it is well stated that rebuilding the loblolly pine forests, in the face of the natural ecological succession toward a hardwood climax, is a real challenge. A section on species and environment deals with the factors involved in the perpetuation of the pine type in this natural succession. These factors are successional trends, physiography and moisture, nutrition and soils, root and shoot growth, photosynthesis, and site quality. It is concluded that the natural reasons for the ascendancy of hardwoods over pine involve soils, roots, and photosynthesis. An important prerequisite to keeping the forests in production is adequate protection. The section on protection includes well illustrated information on the various kinds of injury and damage caused by logging, fire, diseases, climate, and insects. Control measures are given for the destructive agents that play

an important role in the regeneration and management of the forests. One of the major problems in the region is how to get prompt and adequate pine reproduction after a harvest cutting. The chapter on natural regeneration is a thorough coverage of the available information on seed crops, natural seeding, site preparation, and the importance of growing space. Successful reproduction is dependent on the selection of good seed trees, nature of the seedbed, effect of space on seedling height growth, and schedules for release. Artificial regeneration by planting pine seedlings is the quickest and surest means of restocking forest lands. It is estimated there are 29 million acres in the South in need of planting. The section on artificial regeneration is concerned with the need for planting, choice of species and site, seed source, seed procurement, direct seeding, nursery practice, planting, and tree improvement through selection and breeding. Control measures are given for the destructive agents that attack nursery stock. Well defined guidelines are given for some of the more important reforestation practices such as the silvical and economic aspects of spacing, and the influence of seed source on growth. The next step in good silvicultural practice is the evaluation of the capacity of the trees and stands for growth and yield. Research on crop trees, equilibrium density versus desirable stocking, expression and regulation of density, growing stocks and increment, and estimating raw material is reviewed with numerous tables and graphs, under growth and yield. The management of loblolly pine is particularly difficult when the stand is mixed pine and hardwoods. The chapter on the management of immature timber offers recommendations for stand improvement, thinning, and pruning. Procedures are given for the disposal of surplus and inferior trees through the use of silvicides. One of the most complex problems involved in handling loblolly is how to determine which of the silvicultural harvesting procedures will adequately regenerate the new stand. The section on management of mature timber deals with the merits of the four main harvesting systems, the financial aspects of handling loblolly pine timber, economic log and tree size, and optimum stocking for profitable operation. The final chapter on properties and uses of wood presents a thorough and well illustrated discussion of anatomical features, pulping properties, properties related to strength, defect and grade, seasoning, and preservation. The appendix has 12 tables on lumber dimensions, log grades, pulpwood volumes, and timber volumes.

This book is more than a monograph on loblolly pine, because it is an outstanding book on Southern forestry. For many years to come, Wahlenberg's *Loblolly Pine* will be a valuable handbook for foresters in the South as well as required reading in the forestry schools.

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The Biology of Weeds. Edited by John L. Harper. British Ecological Society Symposium Number One. 256 pp. illus. Blackwell Scientific Publications, Oxford. 1960. 42s.

During the past 80 to 100 years the study of plants useful to man has become, for the first time since the era of the herbalists, once more a respectable occupation for professional botanists. However, according to the editor of this volume, botanic as distinct from agronomic concern with man's plant antagonists is more recent, having developed in the last 10 to 15 years.

The papers in this symposium demonstrate the suitability of weeds as research subjects and the propriety of the classical fields of botany and ecology in the study of the biology of weeds. The contributions are significant in methodology and in conclusions dealing with systematics, synecology, autecology, and specialized morphology of a number of weedy plants. Although the nuisance aspect of weeds receives considerable attention in some of the papers, there is no major attempt to discuss herbicide use; rather, the value to weed-control of an understanding of weed biology is at least implicit in every paper.

The volume includes, following an introduction, review and substantive papers on: "Taxonomy and Evolution in Weeds"; Dormancy and Dispersal of Weed Seeds;" "Population Studies . . .;" "Special Weed

Problems," dealing with woody, aquatic, and parasitic weeds; and "Autoecological Studies . . ." A bibliography is at the end of each paper. A general review of cytogenetics, particularly polyploidy, in disturbed vegetation would have been appropriate, especially because there is a number of English and German workers (botanists of both countries contributed to this symposium) interested in this problem.

Every author writing about weeds seems to feel obligated to offer a general definition of a weed. Perhaps because the term "weed" is of Anglo-Saxon origin and has neither standing nor equivalent in strict botanic terminology, authors who define the term seldom appear constrained to cite anyone else's definition. In the introduction to *The Biology of Weeds* the editor cites "weeds . . . higher plants which are a nuisance" as a practical definition for the purposes of this symposium. Several of the contributors then proceed to supply their own definitions, not necessarily at odds with that in the introduction, but their own nevertheless. Reporting on the taxonomy of the sun-loving British knotgrasses, Styles defines weeds as plants of open habitats invading bare ground at an early successional stage. This is an important recognition of the necessity of including an ecologic as well as an economic (nuisance) criterion, but what about the *Viola* species, *Eichornia*, and some other plants discussed in this volume that are unquestionably weeds but that are not invaders of bare ground?

Of particular interest to ethnobotanists will be Godwin's paper on the history of weeds in Britain; Bunting's discussion of the relationship of weeds to cultivation and to the ruderal origins of crops; Little's presentation of the ecology of some New Zealand woody weeds; and Gay's discussion of the water hyacinth in the Sudan.

The British Ecological Society, the editor, the contributors, and the publishers are to be congratulated on the rapid appearance of this volume, which was published within a year after the symposium. If the absence of an index is a casualty of the dispatch in publication, it is the only one apparent. Figures and tables throughout the text are uniform in construction and thoroughly legible. The three plates are sharp and clear. The typography and format are pleasing.

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Weed Control Handbook. Edited under the direction of E. K. Woodford. 2nd ed. 264 pp. illus. Blackwell Scientific Publications, Oxford, 1960. $4.50.

This treatise should more properly be termed a chemical weed-control handbook. Its objectives are succinctly presented in the preface:

"The handbook is intended for all who are interested in the practical or technical aspects of the subject and the aim has been to make the volume complete; to cover all questions that can arise in the chemical control of weeds. Thus it deals with those weed killers which are established in use and also gives the available information about those which are not yet fully proven, their chemistry, their effects and recommended dosages. It lists the weeds and their susceptibilities, the crops and their resistances. Methods of application of herbicides are described and sections are devoted to such matters as spray drift and the legal aspects of herbicide use. If anything has been omitted the Committee would like to know about it . . ."

Within the limits as defined, the *Weed Control Handbook* is indeed a valuable compendium and has no contemporary parallel on the American continent. It systematically and thoroughly treats properties, herbicidal virtues and short-comings, method of application, etc., for most weed killing chemicals employed in temperate agriculture. For example, the chemical, physical, and mammalian toxicity characteristics of 71 herbicidal compounds are summarized in a lengthy table. The herbicidal effect of nine different chemicals on 209 kinds of weeds is similarly tabulated. There is an extensive and detailed treatment of the tolerance of crops to herbicides. Specific chapters deal with woody and aquatic weeds, forest nurseries, lawns and turf, and uncropped land. The application of herbicides (care and operation of machinery, dosages, use of mixtures, etc.) receives careful consideration. All in all, a considerable amount of meticulously desiccated and detailed information is packed into a small space.

The mode of treatment, however, imposes some rather severe limitations. Presenting, in large part, direct recommendations applicable specifically to British agriculture, much of the content is less applicable elsewhere than if more emphasis were placed upon principles. And unfortunately, it seems to me, little or no effort is made to orient chemical weed control to weed control otherwise: in relation to mechanical and cultural methods, crop rotations or sequences, considerations of crop-weed competition, etc. There is little reference to the integration of weed control procedures in a total farming program. One is left with the impression that weeds are controlled with chemicals—period.

The advisability of any weed control procedure must be based upon considerations of cost versus gain. The employment of many kinds of herbicides is quite expensive. For example blanket coverage with a given pre-emergence herbicide in corn might at a specific dosage result in yield benefits averaging $12.00 an acre. But if the cost (chemical plus application) is $15.00, the merit of the undertaking is probably dubious. Band treatment with the same herbicide, the use of another herbicide (2, 4-D is the cheapest for such a purpose) or, alternatively, the employment of the rotary hoe might yield less satisfactory control on an absolute scale, but if the costs were at a level that would allow the farmer to come out on the positive side of the ledger, the employment of such procedures should receive careful consideration.

The *Handbook* seems virtually to ignore these economic aspects of weed control—which surely exist in the British Isles as well as in the United States. Perhaps such considerations are prefabricated into some of the recommendations, but I find little evidence of this.

One somewhat anomalous section, "Notes on some individual weeds and methods of control" (16 pages within the chapter, "The effect of herbicides on weeds"), constitutes an exception to certain of the above generalizations. Here there are random explorations into various phases of weed control as they refer to specific weed kinds. The biology, growth habits, and identification characters of some of the species are discussed.

The *Weed Control Handbook*, if employed within proper context, should be a useful reference for workers in the weed control field.

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Vorläufiges Verzeichnis Landwirtschaftlich oder Gärtnerisch Kultivierter Pflanzenarten. Rudolph Mansfield. (*Die Kulturpflanze*, Beiheft 2.) 659 pp. Akademie-Verlag, Berlin, 1959. 65 DM.

The *Verzeichnis* is the last major publication by the late Dr. Mansfeld, who was curator of the Institute für Kulturpflanzenforschung, Gatersleben, German Democratic Republic. The author is well known for his work on the taxonomy and nomenclature of orchids and of cultivated economic plants and related wild species, especially of temperate zones.

This volume contains entries for about 1430 species of cultivated plants, arranged according to the Englerian system. Plants grown solely for ornament are not included. For each entry are given the scientific name; a listing of synonymy; common names, frequently in several languages (including English, German, French, Spanish, Italian, and Russian); range or area of origin; area of cultivation; and use. Generic synonymy is included, and for each genus the type species is listed. The book closes with separate indices to common and scientific names. Doubtless because of considerations of space, no bibliography is to be found in the *Verzeichnis*, although the book obviously is based in large part upon literature.

Dr. Mansfeld attempted to bring nomenclature in his book into harmony with the *International Code*; he appears to have been successful. He avoided as far as possible the creation of new combinations. Perhaps the major nomenclatorial innovation is the change in name of the watermelon from *Citrullus vulgaris* to *C. lanatus*.

The *Verzeichnis* is unique in concept. I know of no other attempt to bring together in systematic arrangement the kinds of data found in the book, which is, for those cultivated plants it covers, at once a standard of nomenclature, a dictionary of

common names, and a compendium of basic information on use. The work will be found valuable as a reference book by all who are interested in cultivated plants.

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Die Nutzpflanzen der Tropen und Subtropen der Weltwirtschaft. Ilse Esdorn. 158 pp. illus. Gustav Fischer Verlag, Stuttgart, 1961. DM 24.

This book has been written for use in universities, high schools, and technical schools and for reference purposes. It is particularly welcome since a modern book on this subject in German was not previously available. The author has a very extensive knowledge of utilitarian plants that she has acquired during many years as a lecturer at the Institute of Applied Botany in the University of Hamburg and during innumerable visits to the tropics. The plants described were selected from the point of view of their importance in world trade. Only tropical and sub-tropical plants are described, excluding those that have been acclimatized in temperate zones. Pests and diseases are not discussed. Medicinal, ornamental, and wood-supplying plants are omitted.

The first section is devoted to starch- and flour-supplying plants: rice, millet, manioc, batate or sweet potato, yam, and arrowroot. Section two is concerned with sugar cane. Section three deals with oil- and fat-producing plants: soybean, peanut, coconut palm, oil palm, the olive, sesame, castor bean, the tung tree, babaçú palm, oiticica, shea butter, and the argan tree. Section four is a treatment of stimulant-producing plants such as Chinese and Paraguay tea, coffee, cocoa, and cola. Spice-producing plants follow, including pepper, cinnamon, ginger, nutmeg, cloves, cardamom, vanilla, turmeric, and allspice. Fruit-supplying plants are dealt with in the sixth section: citrus species, banana, pineapple, date palm, and the carob tree. Discussed next are plants that supply mucilages and gums, including tragacanth, karaya, and Arabic. Much space is devoted to fiber-producing plants such as cotton, kapok, jute, ramie, sunn hemp, kenaf, Manila hemp, sisal, Yucatan sisal, cantala, istle, raphia, crin vegetal, New Zealand flax, Mauritius hemp, and Ceylon bowstring hemp. Then there is a description of plants that supply rubber, gutta percha, and chicle. Sections on copal and tannins are also included.

For each plant discussed there is a description of structure, habitat, regions where grown, production, the processing or raw material (including manufacture), economic importance, and export and import statistics. The statistical data provided are valid up to and including 1957. Thirty-four excellent line drawings of whole plants or parts of plants illustrate the text.

This handy and useful book can be recommended to those who are looking for an introduction to the study of morphological, chemical and economic aspects of useful tropical and sub-tropical plants.

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The Search for New Antibiotics. Problems and Perspectives. G. F. Gause. 97 pp. illus. Yale University Press, New Haven, 1960. $4.75.

This book is based upon a lecture given by the noted Russion microbiologist, Professor G. F. Gause, at Yale in 1959. The thesis of Professor Gause's lecture is that screening programs for antibiotics and anticancer agents need not be conducted empirically since three "principles representing the scientific basis of the search have already been discovered." His book is devoted to the exposition of the three principles, which are: first, that there exists an ecology and geography to antibiotic-producing microorganisms (20 pages); second, that antibiotic production is to a significant degree species-specific (7 pages); and third, that test organisms can be developed which, by virtue of their biological equivalency with cancer cells, can be used effectively to detect anticancer agents (59 pages).

Professor Gause is most convincing in the development of his third principle, which is based upon the possible analogy between respiration-deficient mutants of bacteria, yeasts, and protozoa and presumed respiration-deficient cancer cells (*in sensu* War-

burg). He presents strong evidence that compounds which specifically inhibit the growth of some cancer cells also specifically inhibit the growth of certain respiration-deficient microbial mutants. Antibiotics which do not inhibit cancer cells inhibit both parent and mutant cells with equal efficiency, or inhibit only the parent cells.

Soil microbiologists should be particularly interested in the development of the first principle, which concerns a correlation between temperature and altitude of the land and the type of antibiotic which is frequently produced by the members of the soil flora. Less convincing is the evidence that a knowledge of the identity of an organism which produces an antibiotic would be of use during the early phase of a screening program.

The book is not a reference book (there are 118 references) but it is stimulating reading from several points of view. One cannot help but feel, however, that Professor Gause's case would have been presented more convincingly had he listed useful antibiotics and anticancer agents that have been discovered in Russia.

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